NOAA Technical Memorandum NOS NGS 21

HAYSTACK-WESTFORD SURVEY

Rockville, Md.
September 1979

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NOAA geodetic publications

Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys. Federal Geodetic Control Committee, John O. Phillips (Chairman), Department of Commerce, NOAA, NOS, 1974 reprinted annually, 12 pp (PB265442). National specifications and tables show the closures required and tolerances permitted for first-, second-, and third-order geodetic control surveys.

Specifications To Support Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys. Federal Geodetic Control Committee, John O. Phillips (Chairman), Department of Commerce, NOAA, NOS, 1975, reprinted annually, 30 pp (PB261037). This publication provides the rationale behind the original publication, "Classification, Standards of Accuracy, ..." cited above.

NOAA Technical Memorandums, NOS/NGS subseries

NOS NGS-1 Use of climatological and meteorological data in the planning and execution of National Geodetic Survey field operations. Robert J. Leffler, December 1975, 30 pp (PB249677). Availability, pertinence, uses, and procedures for using climatological and meteorological data are discussed as applicable to NGS field operations.

NOS NGS-2 Final report on responses to geodetic data questionnaire. John F. Spencer, Jr., March 1976, 39 pp (PB254641). Responses (20%) to a geodetic data questionnaire, mailed to 36,000 U.S. land surveyors, are analyzed for projecting future geodetic data needs.

NOS NGS-3 Adjustment of geodetic field data using a sequential method. Marvin C. Whiting and Allen J. Pope, March 1976, 11 pp (PB253967). A sequential adjustment is adopted for use by NGS field parties.

NOS NGS-4 Reducing the profile of sparse symmetric matrices. Richard A. Snay, June 1976, 24 pp (PB-258476). An algorithm for improving the profile of a sparse symmetric matrix is introduced and tested against the widely used reverse Cuthill-McKee algorithm.

NOS NGS-5 National Geodetic Survey data: availability, explanation, and application. Joseph F. Dracup, June 1976, 45 pp (PB258475). The summary gives data and services available from from NGS, accuracy of surveys, and uses of specific data.

(Continued at end of publication)

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W. E. Carter, C. J. Fronczek
and J. E. Pettey

National Geodetic Survey
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UNITED STATES
DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION
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National Ocean
Survey
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ABSTRACT. A special purpose three-dimensional geodetic survey was conducted in the vicinity of the Haystack-Westford Radio Observatory complex near Boston, Mass. The survey included a high accuracy network connecting points of interest within the observatory complex and connections to the North American Datum (NAD) and the National Geodetic Vertical Datum (NGVD). Extraordinary efforts were made to determine the components ΔX_E, ΔY_E, ΔZ_E of the Very Long Base Line Interferometry (VLBI) vector base line to the highest possible accuracy between the Haystack and Westford radio telescopes. This report contains descriptive information on the methods employed in the collection, reduction, and analysis of the survey data, tabulations of the observational data, and numerical and interpretative results of our analysis.

INTRODUCTION

The results are given for a special purpose study conducted by the National Geodetic Survey (NGS), an office of the National Ocean Survey (NOS), NOAA, in the vicinity of the Haystack-Westford Radio Observatory complex near Boston, Mass.

The survey had three major goals:

- To determine the locations of the Westford and Haystack radio telescopes relative to the North American Datum and the National Geodetic Vertical Datum.

- To determine accurately the relative locations of the Haystack VLBI, Doppler, and intercomparison-validation reference marks.

- To determine in a well defined coordinate system the magnitude and orientation of the vector base line between the VLBI reference points at the Haystack and Westford radio telescopes.

Since the survey required expertise within several specialized geodetic areas, it was planned and managed by a special work group. W. E. Carter served as Project Manager and C. F. Fronczek was Special Technical Advisor. Field Operations were performed by geodetic teams G23,

G-37, and G-47, under the direction of the party chiefs, H. D. McKinney, D. C. Frazier, and R. S. Cohen, respectively.

The final adjustment of the survey was performed by using computer program HAVAGO (Horizontal and Vertical Adjustment of Geodetic Observations). HAVAGO was developed by T. Vincenty (1979) of NGS for special purpose surveys which combine horizontal, vertical, astronomic, and electromagnetic distance measuring (EDM) observations in a three-dimensional adjustment. The input for HAVAGO is listed in appendix A. Output is shown in appendix B.

Close cooperation was received throughout the survey from the Northeast Radio Observatory Corporation (NEROC), which operates the Haystack and Westford Observatories. NEROC was directly responsible for all tasks involving telescope operations and facility modifications.

BACKGROUND

The National Geodetic Survey, NOS, plans to use the Westford Radio Observatory as one of three permanent stations for project POLARIS (POLar motion Analysis by Radio Interferometric Surveying). The project will utilize VLBI observations for monitoring polar motion and Earth rotation (Carter et al. 1978).

The Haystack Observatory has been used for the past several years by VLBI researchers, enabling the determination of very high accuracy base lines between Haystack and several other radio observatories, e.g., National Radio Astronomical Observatory in Greenbank, W. Va.; Owens Valley Radio Observatory, near Bishop, Calif.; and Goldstone Radio Observatory, near Barstow, Calif. These observatories will very likely be used as base stations, in conjunction with transportable VLBI systems, to establish a much more extensive high accuracy network when VLBI becomes an operational geodetic tool. The VLBI base lines have already been used by NGS as a standard to check the Doppler satellite network scale and orientation. The Doppler network will, in turn, be a very important component of the new North American Datum.

Comparative studies of various "space techniques" are being conducted cooperatively by the National Aeronautics and Space Administration (NASA) and NOS/NGS. Methods with geodetic potential include VLBI, satellite laser ranging, lunar laser ranging, and Doppler satellite observations.

The Haystack-Westford Radio Observatory is one of the primary sites being used in these studies. As part of this program a facility suitable for occupancy by transportable laser ranging and VLBI systems has been constructed adjacent to the Haystack Radio Observatory. The measurements made by the various methods refer to different reference points, and the results can be compared only after their reduction to a common reference point. This survey was designed to yield the data necessary to make these reductions.

During the past several years Haystack-MIT (Massachusetts Institute of Technology) researchers have repeatedly used VLBI observations to determine the vector base line from the Haystack radio telescope to the Westford radio telescope. Their results are summarized in Rogers et al. (1978). The only other comparative information available is the result of a survey conducted by a private surveyor, R. Pressey, of Pressey, Inc., Lynn, Mass. Unfortunately, this survey was only designed to yield an accurate length, i.e., the magnitude of the vector base line, and did not address the question of orientation in any meaningful way. The VLBI and survey-determined lengths did agree to better than 1 cm, but the components had differences which were an order of magnitude larger. The NGS survey design was strongly influenced by a desire to determine optimally the components ΔX_E, ΔY_E, ΔZ_E of the Haystack-Westford base line with present operational techniques and reasonable cost constraints.

HAYSTACK-WESTFORD VECTOR BASE LINE

Basic Formulation

The components of a line connecting two stations on the Earth, expressed in a standpoint altitude-azimuth coordinate system are

$$\Delta X_A = B \cos A \cos a$$

$$\Delta Y_A = B \sin A \cos a$$

$$\Delta Z_A = B \sin a$$

where

B is the chord distance between the stations,

A is the azimuth of line B,

a is the altitude (vertical angle) of line B.

Subscript A indicates an altitude-azimuth reference frame.

If the astronomic latitude and longitude of the standpoint (i.e., the direction of the local vertical with respect to the rotational axis of the Earth and the Greenwich meridian) are known, the components can be determined in an equatorial frame of reference. The appropriate equations are

$$\Delta X_E = B\,[\cos\lambda\,(\cos\phi\cos a - \sin\phi\cos A\cos a) - \sin\lambda\cos A\cos a]$$

$$\Delta Y_E = B\,[\sin\lambda\,(\cos\phi\sin a - \sin\phi\cos A\cos a) + \cos\lambda\sin A\cos a]$$

$$\Delta Z_E = B\,[\cos\phi\cos A\cos a + \sin\phi\sin a]$$

where

B, A, a are as previously defined,

ϕ is the astronomic latitude,

λ is the astronomic longitude.

Subscript E indicates an equatorial reference frame.

The concepts and equations which are briefly presented above form the basis for the methods often referred to as three-dimensional geodesy. Several books and papers have been published on the subject, e.g., Heiskanen and Moritz (1967), Bomford (1971) and Rapp (1975).

Survey Scheme

Because of local terrain, vegetation, and obstructions associated with the radio telescopes and their enclosing structures, the VLBI vector base line could not be directly observed. It was necessary to use the survey network shown in figure 1.

The Haystack telescope (fig. 2) has an altitude-azimuth mount. The vertical (azimuth) and horizontal (altitude) axes intersect (any eccentricity is below the resolution of this survey) and the point of intersection is the VLBI reference point for this telescope. There is no physical component at this point, but rather it is a point in space that can be located only with respect to some auxiliary monumented point.

A special marker was designed and fabricated by NEROC and installed on the telescope trunnion. The location of the vertical axis was determined and marked as accurately as the survey techniques would permit. (The uncertainty is estimated to be a few tenths of a millimeter.) This mark was given the station designation HAYSTACK-TRUNNION. It is located directly below the intersection of axes at a location suitable for setting up and operating instruments such as theodolites and EDM units.

NEROC cut two 30-cm-diameter holes in the Haystack radome to allow lines of sight from HAYSTACK-TRUNNION to the instrument points on temporary survey towers at stations OUTER CONTROL POINT (OCP) 2 and MILL.

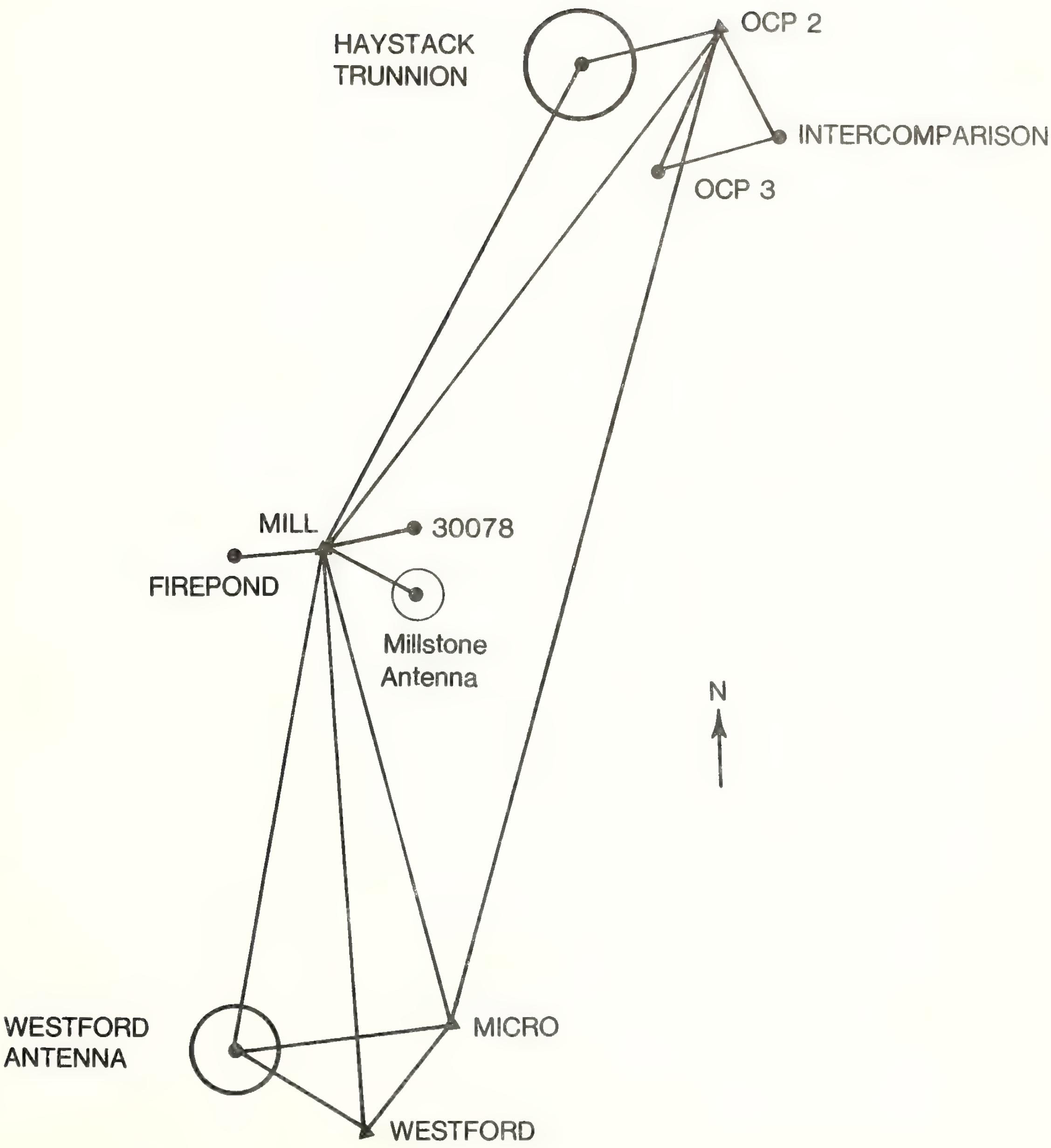

Figure 1.--Haystack-Westford vector base line survey scheme.

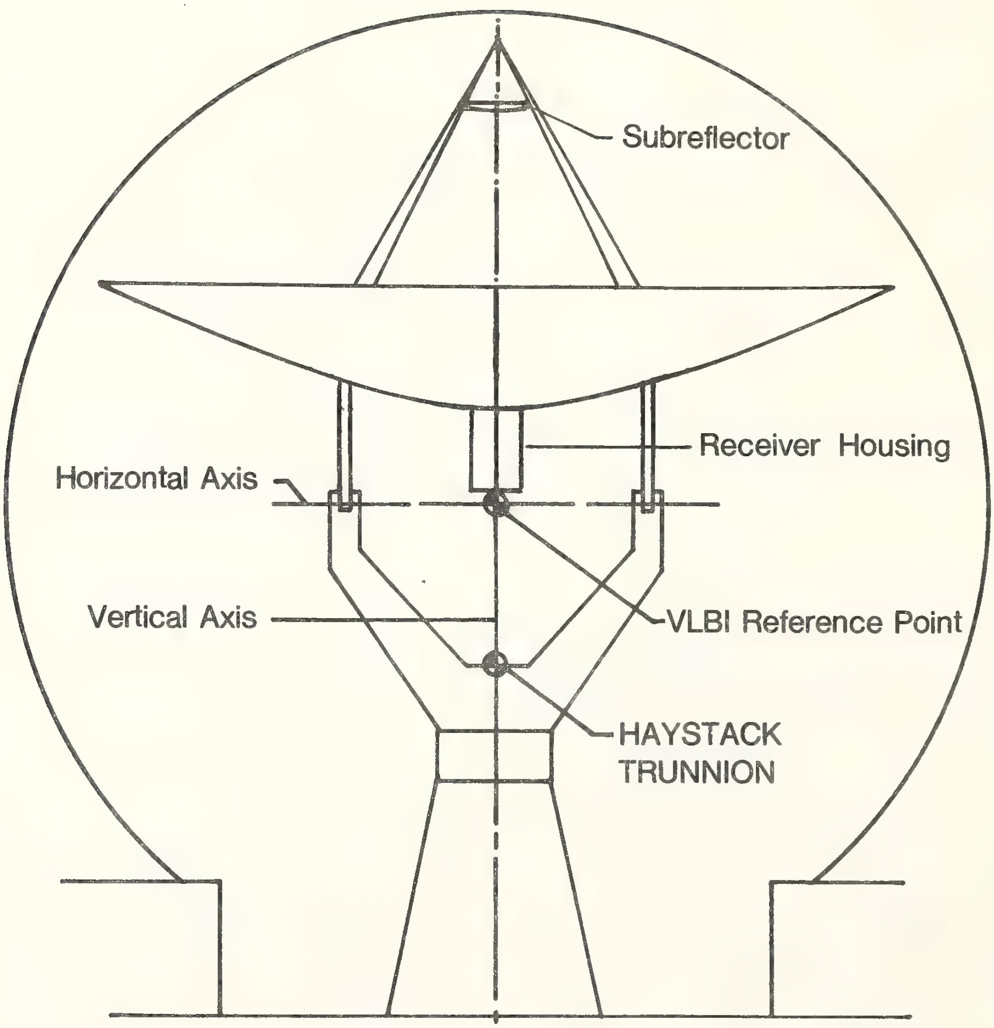

Figure 2.--The Haystack radio telescope is a 37-meter diameter Cassegrainian type instrument with an intersecting axis altitude azimuth mount. It is housed in a 46-meter diameter rigid radome. HAYSTACK TRUNNION is the monumented survey station established during the geodetic survey.

The Westford telescope is also an altitude-azimuth mounted instrument, but the vertical and horizontal axes are offset by more than 0.3 meter. (See fig. 3.) The VLBI reference point is located at the intersection of the vertical axis with the plane containing the horizontal axis. Again, this is a point in space that must be referred to an auxiliary monumented point. A punch mark was made in the steel decking of the telescope directly on the vertical axis. This mark was given the station designation WESTFORD ANTENNA. The Westford telescope was NOT enclosed in a radome during the survey.

Astronomic Observations

Astronomic latitude and longitude were determined at three points in the immediate vicinities of stations WESTFORD, MILL, and OCP 2. The astronomic positions of the remaining stations were considered to be adequately determined because of their close proximity to one of these primary stations, i.e., the deflections were assumed to vary insignificantly for distances of a few tens of meters. Table 1 lists the observed deflections at the three primary stations.

Table 1.--Deflections of the vertical

	Deflections	
Vicinity	ξ (arc sec)	η (arc sec)
OCP 2	-1.75	+0.08
MILL	-1.85	+ .52
WESTFORD	-2.16	+ .79

The longitude determinations were made by the meridian transit method (Hoskinson and Duerksen 1947) using a Wild T-4 theodolite and a Datametrics model SP-300 digital timing system. All the observed stars were taken from the Fourth Fundamental Catalogue (FK4) (Fricke et al. 1963).

The latitude determinations were made by the differential zenith distance method, often referred to as the Horrebow-Talcott method (Hoskinson and Duerksen 1947). The constraints on zenith distance differences and time between transits of the stars forming pairs require a catalog containing a large number of stars. It is not feasible to form acceptable observing lists from the FK4, which only includes approximately 1,500 stars. NGS presently uses the Smithsonian Astrophysical Observatory Star Catalog (SAO 1966) which contains more than 250,000 stars. This catalog has been related to the FK4 through zonal corrections.

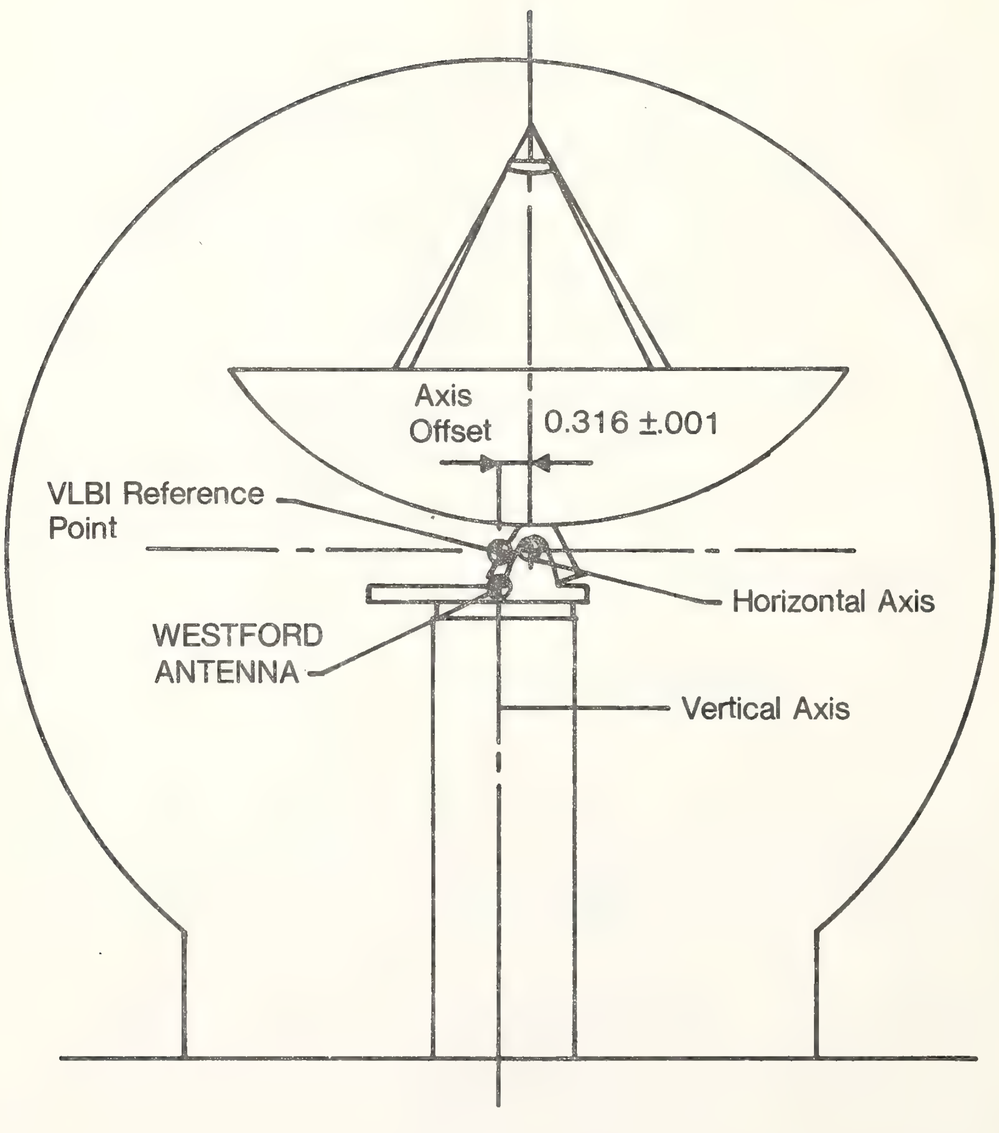

Figure 3.--The Westford radio telescope is an 18-meter diameter Cassegrainian type instrument with an eccentric (nonintersecting) axis altitude-azimuth mount. It is housed in a 30-meter diameter inflated radome. WESTFORD ANTENNA is the monumented survey station established during the geodetic survey.

Both the latitude and longitude determinations included observations by two observers to minimize personal biases. Observations were made on two or more nights to reduce anomalous refraction errors. In addition, the sequences of observations were changed between nights to broaden the spans of right ascension covered by the observations.

Astronomic azimuths were observed by the "direction method" (Hoskinson and Duerksen 1947) using POLARIS at any hour angle. Analyses of astronomic azimuths have shown that the determinations are contaminated by significant systematic errors such as observer bias and instrumental biases (Carter et al. 1978). To minimize the effects of these systematic errors, a multiplicity of instruments and observers were employed. Observations were repeated on different nights and the intensities of the target lights were adjusted to resemble (as closely as possible) the star. All azimuths were observed with Wild T-3 theodolites. For the few lines not directly included in the azimuth observational program (very short lines) azimuth orientations were obtained through angular transfer using horizontal angles measured independently from the azimuth determinations.

It is well known that the orientation of the physical body of the Earth with respect to the axis of rotation varies with time. This phenomenon is commonly referred to as polar motion. Polar motion causes the components of a line expressed in an astronomic reference frame to be time dependent. If multiple determinations of the components made at different epochs are to be compared, the observed values must be reduced to a common epoch. All astronomic latitudes, longitudes, and azimuths used in this survey were reduced to the Conventional International Origin using polar coordinates and time information published by the Bureau International de l'Heure.

Altitude Observations

The altitudes (vertical angles) of the various lines were measured with Wild T-3 theodolites. Because of the shortness of the lines and by the use of surveying towers, which provided good ground clearance along all primary lines, refraction was not a major source of uncertainty in the altitude observations. The main sources of uncertainty resulted from measurements of the heights of the instruments and targets above the marks and from personal and instrumental biases. As with azimuth determinations, an attempt was made to minimize these biases by using several observers, theodolites, and observing periods.

Precise Leveling

Precise leveling was performed among the ground marks. These elevation differences can be included in the three-dimensional adjustment if certain assumptions are made about the behavior of the geoid within the survey area. The assumption most commonly made is that the direction of gravity varies uniformly between the endpoints of a line. Rapp (1975) presents appropriate observation equations for this simple model.

The Haystack-Westford survey is very limited in extent and the terrain is not unusually rugged. The deflections listed in table 1 do not suggest any anomalous geoidal behavior in the area. The simple model appears quite appropriate and was used in this survey adjustment.

Electromagnetic Distance Measurements

Electromagnetic distance measurements were made over all lines of the survey scheme. Three different instrument models were used: Tellurometer MA100, Hewlett Packard 3800, and Ranger IV. All were calibrated immediately prior to their use, and their frequency standards were checked frequently during the survey.

Meteorological measurements to determine the atmospheric index of refraction were collected at regular intervals throughout the EDM observing periods. Experience has shown that, even after the application of all known refraction corrections, scale biases as large as a few parts in 10^6 often exist between EDM made during daylight hours and darkness (Carter and Vincenty 1978). Since the source of bias is not clearly understood, it is not possible to state definitely what relationship exists between the correct scale and daytime or nighttime observations. With the absence of better guidelines, the EDM observing schedules were divided almost equally between daylight and nighttime periods. For this particular survey, the primary sources of errors in the EDM observations were probably instrumental biases and setup (centering).

Comparison with VLBI Results

The components of the Haystack-Westford base line (extracted from appendix B) are given in table 2, along with the values derived from the VLBI experiments. The differences between the ΔY_E and ΔZ_E components are larger (by a factor of 2 to 4) than would be expected from the estimated uncertainties associated with the values. If these values are

Table 2.--Comparison of NGS and VLBI components of the Haystack-Westford vector base line in an equatorial reference frame

Components	NGS m	VLBI m	Difference NGS-VLBI m
ΔX_E	-198.139	-198.139	-0.000
ΔY_E	-863.983	-863.999	+ .016
ΔZ_E	-866.234	-866.223	- .011
B	1,239.390	1,239.394	- .004

transformed to a Haystack altitude-azimuth frame of reference, the discrepancy is almost entirely in the ΔZ_A component (table 3), which

Table 3.--Comparisons of NGS and VLBI components of the Haystack-Westford vector base line in a Haystack altitude-azimuth reference frame

Components	NGS m	VLBI m	Difference NGS-VLBI m
ΔX_A	-1,149.592	-1,149.594	+0.002
ΔY_A	-462.196	-462.200	+ .004
ΔZ_A	-30.024	-30.005	- .019

corresponds closely to a disagreement in the difference in elevation of the two observatories. To ensure that no undetected blunders had been made in the NGS survey, a special team verified the connections between the Haystack VLBI reference point and OCP 2 and Westford VLBI reference point and station WESTFORD 1978. Both connections checked to ±1 mm. Later, the difference in elevation between OCP 2 and WESTFORD 1978 was also verified by the leveling team which made the connection between the Haystack-Westford scheme and the NGVD.

During the reduction, adjustment, and analysis of the survey, tests were run to determine the sensitivity of the solution to the selection and weighting of individual observations. For example, adjustments were made with only the zenith distances, only the leveling, and both the zenith distance and leveling observations included. The a priori uncertainty estimates of the observaions were also varied. The components of the base line varied by only a few millimeters for the solutions based on what we considered plausible data sets. It appeared very unlikely that the base line components determined by the survey could be in error by enough to explain a significant portion of the 0.019 meter discrepancy in ΔZ_A.

Rogers et al. (1978) had pointed out very explicitly that little was known about the gravitational flexures of the two radio telescopes. Because of the disagreement between the NGS and VLBI results, NEROC personnel measured the flexures. They found that the Haystack telescope did exhibit significant flexure. The effect of this flexure on the VLBI base line orientation is qualitatively correct, and quantitatively of the correct order of magnitude. The final numbers were not available in time for inclusion in this report, and will be published elsewhere in a joint NGS-MIT-NEROC paper.

NAD 1927 CONNECTION

The connection to the North American 1927 Datum is shown in figure 4. Both EDM and horizontal directions were observed. WACHUSETTS 2 1896 and TADMUCK (MAGS) 1936 are transcontinental traverse (TCT) stations. This network was included in the survey adjustment performed by program HAVAGO, and all pertinent data are given in appendices A and B.

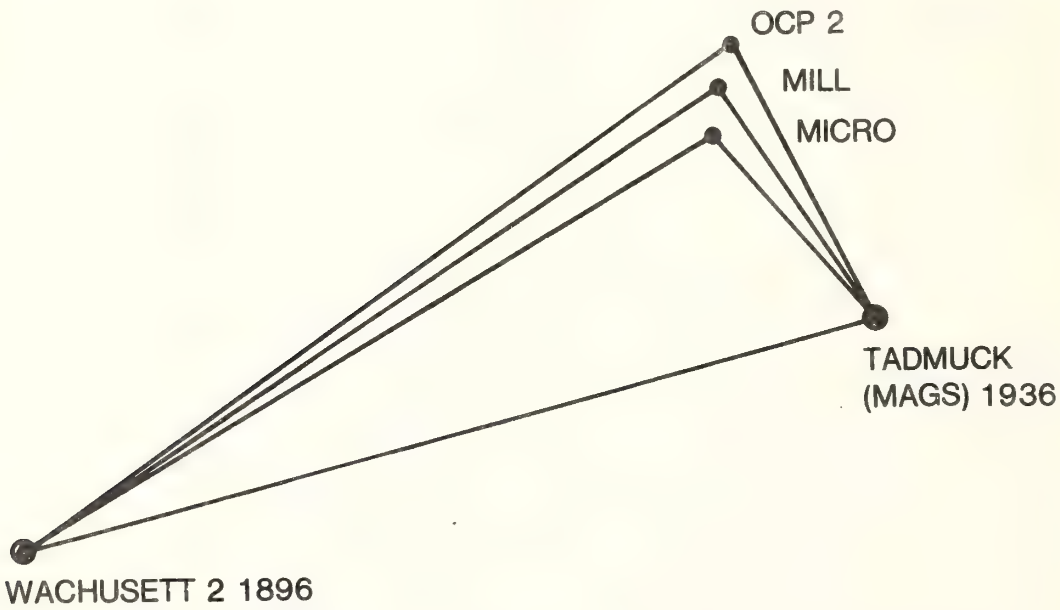

Figure 4.--Connection of Haystack-Westford vector base line survey scheme to NAD.

NGVD 29 CONNECTION

In addition to the precise leveling accomplished as an integral part of the Haystack-Westford vector base line survey, a first-order, class I level line was run to connect the local scheme to the National Geodetic Vertical Datum (NGVD). The spur line is 24.4 km in length and connects to the first-order network at Lowell, Mass., at bench mark Z33. Figure 5 shows the path of the survey. The field work was completed by a subunit of Party G-37, under the supervision of R. Taylor. An adjustment was performed by the NGS Vertical Network Branch, holding the elevation of bench mark Z33 fixed at the NGVD 29 value of 46.410 m. The resulting normal orthometric heights are listed in appendix C.

GRAVITY SURVEY

Gravity measurements were made along the level line that connects to the NGVD 29 and at several survey marks within the observatory complex. Ties were also made to the U.S. National Gravity Base Network (USNGBN). The field work was done by L. M. Johnson, and the data were reduced and adjusted by the NGS Gravity, Astronomy, and Satellite Branch. Results are listed in appendix D.

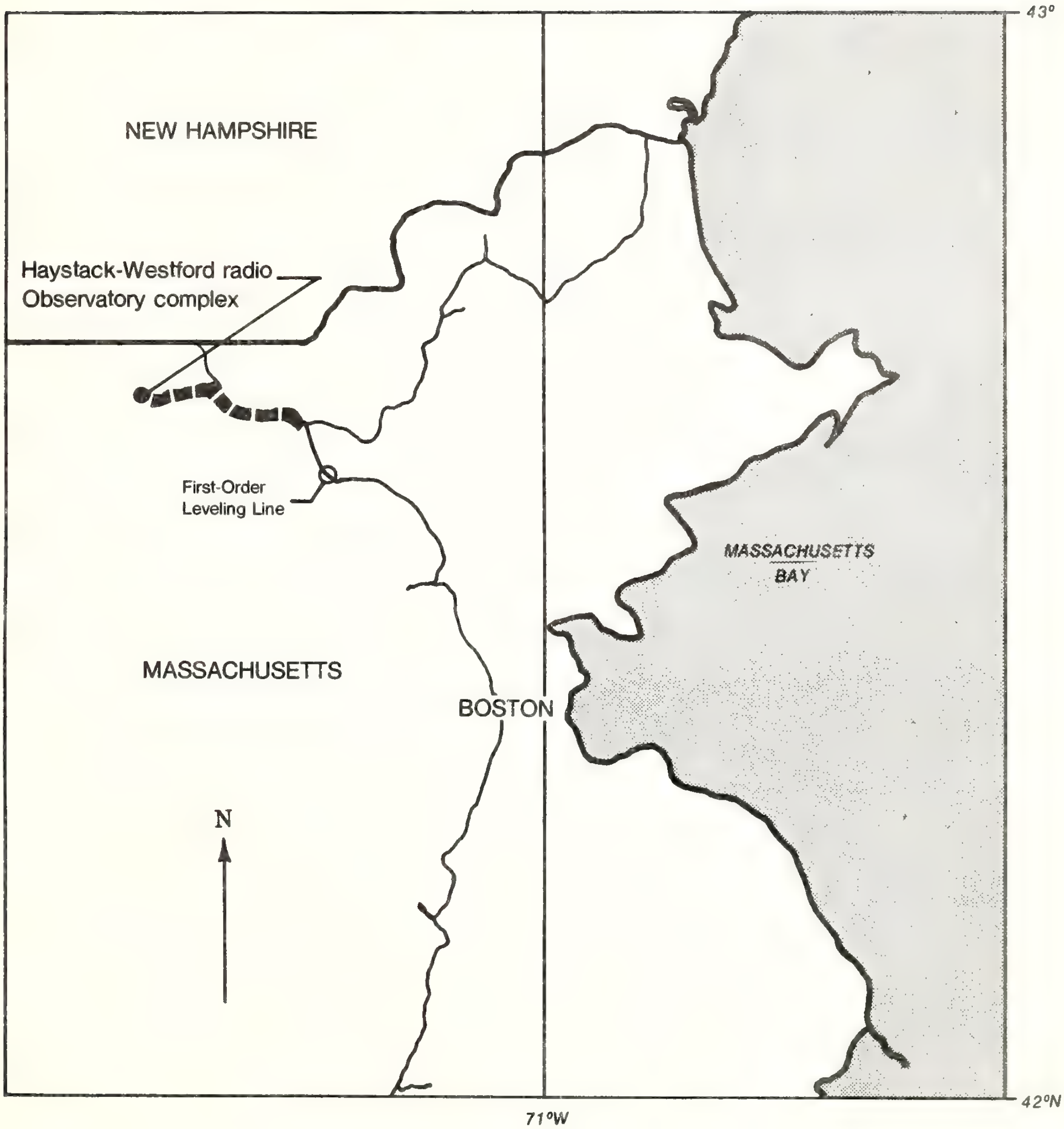

Figure 5.--Connection of Haystack-Westford Radio Observatory complex to National Geodetic Vertical Datum. Heavy dashed line indicates route of new leveling.

REFERENCES

Bomford, G., 1971: Geodesy. Clarendon Press, Oxford, third edition, 731 pp.

Carter, W. E., Pettey, J. E., and Strange, W. E., 1978: The accuracy of astronomic azimuth determinations, Bulletin Géodésique, 52(2), 107-113.

Carter, W. E. and Vincenty, T., 1978: Survey of the McDonald Observatory radial line scheme by relative lateration techniques. NOAA Technical Report NOS 74 NGS 9, 33 pp.

Carter, W. E., Robertson, D. S., and Abell, M. D., 1978: An improved polar motion and Earth rotation monitoring service using radio interferometry. Proceedings of the International Astronomical Union Symposium No. 82, Spain, in press.

Fricke, W., Kopff, A., et al., 1963: Fourth Fundamental Catalogue (FK4). Veröff. des Astron. Rechen-Instituts Heidelberg, No. 10.

Heiskanen, W. A. and Moritz, H., 1967: Physical Geodesy. Freeman and Co., San Francisco and London, 364 pp.

Hoskinson, A. J. and Duerksen, J. A., 1947: Manual of geodetic astronomy. Special Publication 237, U.S. Coast and Geodetic Survey (now National Ocean Survey, NOAA), Department of Commerce, Washington, D.C., 205 pp. (National Technical Information Service accession #PB267465).

Rapp, R. H., 1975: Geometric geodesy notes, vol. II, Ohio State University, Columbus, pp. 111-134.

Rogers, A. E. E., Knight, C. A., Hinteregger, H. F., Whitney, A. R., Counselman, C. C., Shapiro, I. I., Gourevitch, S. A., Clark, T. A., 1978: Geodesy by radio interferometry--determination of a 1.24 kilometer baseline vector with ∿5 millimeter repeatability, Journal of Geophysical Research 83 (B1), 325-334.

SAO (Smithsonian Astrophysical Observatory) (staff of) 1966: Star catalog. Positions and proper motions of 258.997 stars for the epoch and equinox of 1950.0. Publications of the Smithsonian Institution of Washington, D.C. No. 4562, Smithsonian Institution, Washington, D.C., vols. 1-4.

Vincenty, T., 1979: The HAVAGO three-dimensional adjustment program. NOAA Technical Memorandum NOS NGS-17, 18 pp.

APPENDIX A.--INPUT DATA FOR ADJUSTMENT

Program HAVAGO produced the following computerized listing of input observational data for the survey.

STATION DATA

STATION NUMBER	GEODETIC LAT. ASTRONOMIC LAT.	GEODETIC LON. ASTRONOMIC LON.	GEOD.HT.	GEOD. ASTR.	ST. ERRORS (M) ST. ERRORS		STATION NAME X Y	CODES Z
1	42 36 45.82232	71 29 38.69783	95.642	0.0	0.0	0.001	WESTFORD	0 0 1
1	42 36 43.66	71 29 39.77		0.30	0.40			
4	42 37 2.89005	71 29 31.22933	127.152	0.0	0.0	0.0	MILL	0 0 0
4	42 37 1.04	71 29 31.94		0.30	0.40			
7	42 36 48.25866	71 29 33.62237	112.052	0.0	0.0	0.0	MICRO	0 0 0
7	0 0 0.0	0 0 0.0		10.00	15.00			
10	42 37 22.74701	71 29 16.38480	120.836	0.0	0.0	0.0	HAYSTACK OCP NO 2	0 0 0
10	42 37 21.00	71 29 16.49		0.30	0.40			
11	42 37 23.50566	71 29 19.14139	138.027	0.0	0.0	0.0	HAYSTACK TRUNNION	0 0 0
11	0 0 0.0	0 0 0.0		10.00	15.00			
12	42 36 46.24993	71 29 39.41933	113.506	0.0	0.0	0.0	WESTFORD ANTENNA	0 0 0
12	0 0 0.0	0 0 0.0		10.00	15.00			
13	42 29 20.25131	71 53 13.98092	611.700	0.0	0.0	0.0	WACHUSETT 2 1937	0 0 0
13	42 29 17.60	71 53 8.70		0.30	0.40			
19	42 34 35.87200	71 26 33.00000	142.800	0.001	0.001	0.0	TADMUCK MAGS 1936	1 1 0
19	42 34 33.90	71 26 34.57		0.30	0.40			
24	42 37 2.73524	71 29 27.45756	127.715	0.0	0.0	0.0	MILLSTONE APCS	0 0 0
24	0 0 0.0	0 0 0.0		10.00	15.00			
25	42 37 2.86183	71 29 34.08861	136.197	0.0	0.0	0.0	FIREPOND DMA	0 0 0
25	0 0 0.0	0 0 0.0		10.00	15.00			
26	42 37 2.50380	71 29 28.98173	150.923	0.0	0.0	0.0	MILLSTONE N UPPER WALKWAY	0 0 0
26	0 0 0.0	0 0 0.0		10.00	15.00			
27	42 37 4.08402	71 29 29.11892	139.972	0.0	0.0	0.0	30078 DMA	0 0 0
27	0 0 0.0	0 0 0.0		10.00	15.00			
29	42 37 21.48264	71 29 19.25794	120.791	0.0	0.0	0.0	HAYSTACK OCP NO 3 1975	0 0 0
29	0 0 0.0	0 0 0.0		10.00	15.00			
30	42 37 21.34077	71 29 17.27898	120.740	0.0	0.0	0.0	HAYSTACK INTER COMP	0 0 0
30	0 0 0.0	0 0 0.0		10.00	15.00			
31	42 37 21.20663	71 29 16.20857	120.231	0.0	0.0	0.0	HAYSTACK INTER COMP RM 1	0 0 0
31	0 0 0.0	0 0 0.0		10.00	15.00			
32	42 37 22.73177	71 29 19.62479	121.578	0.0	0.0	0.0	HAYSTACK OCP NO 3 RM 1	0 0 0
32	0 0 0.0	0 0 0.0		10.00	15.00			
33	42 37 21.85528	71 29 18.25324	120.926	0.0	0.0	0.0	HAYSTACK OCP NO 3 RM 2	0 0 0
33	0 0 0.0	0 0 0.0		10.00	15.00			

STATION DATA

STATION NUMBER	GEODETIC LAT. / ASTRONOMIC LAT.	GEODETIC LON. / ASTRONOMIC LON.	GEOD.HT.	GEOD. ST. ERRORS (M) / ASTR. ST. ERRORS			STATION NAME / X	Y	Z	CODES
38	42 37 23.50566	71 29 19.14139	145.327	0.0	0.0	0.0	HAYSTACK VLBI			0 0 0
38	0 0 0.0	0 0 0.0		10.00	15.00					
39	42 36 46.24993	71 29 39.41933	115.422	0.0	0.0	0.0	WESTFORD VLBI			0 0 0
39	0 0 0.0	0 0 0.0		10.00	15.00					

DIRECTIONS

	FROM	TO	LIST	OBSERVED	MM	SEC.
1	30	4	1	0 0 0.0	1.0	1.2
2	30	29	1	66 21 43.31	1.0	1.2
3	30	10	1	175 58 30.62	1.0	1.2
4	30	31	1	250 26 51.50	1.0	1.2
5	31	4	1	0 0 0.0	1.0	1.2
6	31	29	1	65 46 57.89	1.0	1.2
7	31	30	1	68 25 30.12	1.0	1.2
8	31	10	1	143 58 0.99	1.0	1.2
9	10	19	1	0 0 0.0	1.0	0.7
10	10	7	1	56 9 34.94	1.0	0.7
11	10	4	1	64 48 7.61	1.0	0.7
12	10	13	1	101 36 55.54	1.0	0.7
13	10	19	3	0 0 0.0	1.0	3.0
14	10	33	3	93 1 26.80	1.0	3.0
15	10	29	3	95 6 27.70	1.0	3.0
16	10	32	3	125 32 15.60	1.0	3.0
17	10	4	4	0 0 0.0	1.0	0.7
18	10	29	4	30 18 17.03	1.0	0.7
19	10	31	4	326 15 54.48	1.0	0.7
20	10	30	4	356 14 56.92	1.0	0.7
21	10	7	5	0 0 0.0	1.0	1.2
22	10	4	5	8 38 33.46	1.0	1.2
23	29	4	1	0 0 0.0	1.0	1.2
24	29	32	1	142 19 35.00	1.0	3.0
25	29	10	1	213 46 33.78	1.0	1.2
26	29	33	1	217 53 49.20	1.0	3.0
27	29	30	1	250 6 33.10	1.0	1.2
28	29	31	1	251 33 6.02	1.0	1.2
29	11	4	1	0 0 0.0	1.0	0.7
30	11	10	1	267 1 15.42	1.0	0.7
31	7	19	1	0 0 0.0	1.0	0.7
32	7	1	1	102 13 48.65	1.0	0.7
33	7	12	1	110 6 55.80	1.0	0.7
34	7	4	1	232 8 11.85	1.0	0.7
35	7	10	1	245 30 28.61	1.0	0.7
36	7	19	3	0 0 0.0	1.0	0.7
37	7	1	3	102 13 57.14	1.0	3.0
38	7	12	3	110 7 4.38	1.0	3.0
39	7	4	3	232 8 10.91	1.0	0.7
40	7	10	3	245 30 28.70	1.0	0.7
41	7	19	9	0 0 0.0	1.0	0.7
42	7	1	9	102 13 52.20	1.0	1.1
43	7	12	9	110 7 0.09	1.0	1.2
44	7	13	9	112 16 44.53	1.0	0.7
45	7	10	9	245 30 25.95	1.0	0.7
46	4	19	1	0 0 0.0	1.0	0.7
47	4	7	1	48 45 22.17	1.0	0.7
48	4	1	1	59 46 47.35	1.0	0.7
49	4	11	1	245 16 56.69	1.0	0.7
50	4	10	1	250 46 17.74	1.0	0.7

DIRECTIONS

	FROM	TO	LIST	OBSERVED	MM	SEC.	
51	4	19	8	0 0 0.0	1.0	0.7	
52	4	7	8	48 45 21.48	1.0	0.7	
53	4	13	8	108 15 41.79	1.0	0.7	
54	4	10	8	250 46 15.22	1.0	0.7	
55	4	27	8	274 24 57.69	1.0	1.2	TRANS. FROM COMB.LST
56	4	10	10	0 0 0.0	1.0	0.7	
57	4	7	10	157 59 5.17	1.0	0.7	
58	4	10	14	0 0 0.0	1.0	1.2	
59	4	24	14	64 16 37.96	1.0	1.2	
60	4	26	14	74 11 39.28	1.0	1.2	
61	4	1	14	169 0 33.71	1.0	1.2	
62	4	25	14	240 19 53.89	1.0	1.2	
63	19	13	1	0 0 0.0	1.0	0.7	
64	19	7	1	59 33 42.50	1.0	0.7	
65	19	4	1	62 56 28.09	1.0	0.7	
66	19	10	1	68 54 35.85	1.0	0.7	
67	19	13	2	0 0 0.0	1.0	0.7	
68	19	7	2	59 33 38.22	1.0	0.7	
69	19	4	2	62 56 24.69	1.0	0.7	
70	19	10	2	68 54 33.70	1.0	0.7	
71	19	13	3	0 0 0.0	1.0	0.7	
72	19	7	3	59 33 37.20	1.0	0.7	
73	19	4	3	62 56 24.37	1.0	0.7	
74	19	10	3	68 54 32.53	1.0	0.7	
75	13	10	1	0 0 0.0	1.0	0.7	
76	13	7	1	1 18 52.21	1.0	0.7	
77	13	1	1	1 21 14.17	1.0	0.7	
78	13	19	1	9 28 31.38	1.0	0.7	
79	13	10	2	0 0 0.0	1.0	0.7	
80	13	4	2	0 40 39.51	1.0	0.7	
81	13	7	2	1 18 53.01	1.0	0.7	
82	13	1	2	1 21 15.09	1.0	0.7	
83	13	19	2	9 28 32.57	1.0	0.7	
84	13	10	3	0 0 0.0	1.0	0.7	
85	13	4	3	0 40 39.98	1.0	0.7	
86	13	19	3	9 28 32.12	1.0	0.7	
87	1	13	1	0 0 0.0	1.0	0.7	
88	1	4	1	130 50 30.80	1.0	0.7	
89	1	7	1	169 54 43.39	1.0	0.7	
90	1	4	2	0 0 0.0	1.0	3.0	
91	1	7	2	39 4 17.07	1.0	3.0	
92	1	12	2	290 49 33.07	1.0	3.0	

ASTRONOMIC AZIMUTHS

	FROM	TO	OBSERVED	MM	SEC.	
93	4	1	197 54 42.89	1.0	1.4	77 09 27 CWW
94	4	1	197 54 39.98	1.0	1.4	77 10 05 DJN
95	4	1	197 54 44.17	1.0	1.4	77 10 24 DJN
96	4	7	186 53 17.42	1.0	1.4	77 09 28 DJN
97	4	7	186 53 18.36	1.0	1.4	77 09 29 CWW
98	4	7	186 53 15.43	1.0	1.4	77 10 22 CWW
99	4	7	186 53 20.41	1.0	1.4	77 10 23 DJN
100	4	10	28 54 10.40	1.0	1.4	77 09 28 DJN
101	4	10	28 54 12.33	1.0	1.4	77 09 29 CWW
102	4	10	28 54 10.15	1.0	1.4	77 10 22 CWW
103	4	10	28 54 12.44	1.0	1.4	77 10 23 DJN
104	4	11	23 24 48.50	1.0	1.4	77 09 28 CWW
105	4	11	23 24 51.18	1.0	1.4	77 10 05 DJN
106	4	11	23 24 51.89	1.0	1.4	77 10 24 DJN
107	7	4	6 53 16.27	1.0	1.4	77 10 06 DJN
108	7	4	6 53 16.57	1.0	1.4	77 10 06 CWW
109	7	4	6 53 19.09	1.0	1.4	77 10 07 DJN
110	7	4	6 53 15.13	1.0	1.4	77 10 08 CWW
111	7	10	20 15 37.28	1.0	1.4	77 10 06 DJN
112	7	10	20 15 36.66	1.0	1.4	77 10 07 CWW
113	7	10	20 15 40.57	1.0	1.4	77 10 07 DJN
114	7	10	20 15 35.43	1.0	1.4	77 10 08 CWW
115	10	4	208 54 23.78	1.0	1.4	77 09 30 DJN
116	10	4	208 54 22.70	1.0	1.4	77 10 11 DJN
117	10	4	208 54 23.31	1.0	1.4	77 10 22 CWW
118	10	4	208 54 22.61	1.0	1.4	77 10 22 DJN
119	10	4	208 54 22.80	1.0	1.4	77 10 22 CWW
120	10	4	208 54 20.47	1.0	1.5	77 10 12 CWW
121	10	7	200 15 50.44	1.0	1.4	77 09 30 DJN
122	10	7	200 15 48.56	1.0	1.4	77 10 11 DJN
123	10	7	200 15 50.49	1.0	1.4	77 10 22 CWW
124	10	7	200 15 48.01	1.0	1.5	77 10 23 CWW
125	10	7	200 15 47.53	1.0	1.4	77 10 23 CWW
126	10	7	200 15 48.98	1.0	1.4	77 10 12 DJN
127	10	11	290 26 15.67	1.0	1.4	77 10 22 CWW
128	13	19	74 55 32.06	1.0	1.4	73 10 1,9,11 VAR.

GROUPED VERTICAL ANGLES

	FROM	TO	LIST	OBSERVED	MM	SEC.	H.I.	H.T.	K1	K2
129	4	1	1	93 16 21.60	3.0	3.0	0.132	0.0	0.0	0.0
130	4	11	1	90 55 18.80	3.0	3.0	21.966	0.0	0.0	0.0
131	4	1	2	93 16 23.50	3.0	3.0	0.135	0.0	0.0	0.0
132	4	11	2	90 55 19.60	3.0	3.0	22.008	0.0	0.0	0.0
133	4	1	3	93 16 21.40	3.0	3.0	0.135	0.0	0.0	0.0
134	4	11	3	90 55 17.30	3.0	3.0	22.008	0.0	0.0	0.0
135	4	1	4	93 16 57.00	3.0	3.0	0.244	0.0	0.0	0.0
136	4	11	4	90 55 14.50	3.0	3.0	21.996	0.0	0.0	0.0
137	4	7	5	91 25 58.50	3.0	3.0	-3.735	0.0	0.0	0.0
138	4	10	5	90 52 0.60	3.0	3.0	4.246	0.0	0.0	0.0
139	4	7	6	91 25 58.90	3.0	3.0	-3.735	0.0	0.0	0.0
140	4	10	6	90 52 1.00	3.0	3.0	4.246	0.0	0.0	0.0
141	4	7	9	91 26 21.50	3.0	3.0	-3.695	0.0	0.0	0.0
142	4	10	9	90 51 53.20	3.0	3.0	4.241	0.0	0.0	0.0
143	7	4	10	89 0 40.30	3.0	3.0	7.242	0.0	0.0	0.0
144	7	10	10	90 7 56.70	3.0	3.0	11.361	0.0	0.0	0.0
145	7	4	11	89 0 40.50	3.0	3.0	7.242	0.0	0.0	0.0
146	7	10	11	90 7 59.30	3.0	3.0	11.361	0.0	0.0	0.0
147	7	4	12	89 0 40.30	3.0	3.0	7.242	0.0	0.0	0.0
148	7	10	12	90 7 59.80	3.0	3.0	11.361	0.0	0.0	0.0
149	7	4	13	89 0 38.50	3.0	3.0	7.242	0.0	0.0	0.0
150	7	10	13	90 7 57.10	3.0	3.0	11.361	0.0	0.0	0.0
151	10	7	14	90 2 57.10	3.0	3.0	-7.893	0.0	0.0	0.0
152	10	4	14	89 9 23.30	3.0	3.0	-4.028	0.0	0.0	0.0
153	10	7	16	90 2 54.90	3.0	3.0	-7.892	0.0	0.0	0.0
154	10	4	16	89 9 22.50	3.0	3.0	-4.030	0.0	0.0	0.0
155	10	7	18	90 2 57.70	3.0	3.0	-7.892	0.0	0.0	0.0
156	10	4	18	89 9 25.90	3.0	3.0	-4.030	0.0	0.0	0.0
157	1	4	19	86 45 3.00	3.0	3.0	0.041	0.0	0.0	0.0
158	1	7	19	81 40 43.30	3.0	3.0	-3.780	0.0	0.0	0.0
159	1	12	19	103 26 25.00	3.0	3.0	22.903	0.0	0.0	0.0
160	1	4	20	86 44 43.50	3.0	3.0	0.041	0.0	0.0	0.0
161	1	7	20	81 44 38.10	10.0	10.0	-3.591	0.0	0.0	0.0
162	4	19	21	89 55 11.00	3.0	3.0	4.222	0.0	0.0	0.0
163	4	7	21	91 25 53.70	3.0	3.0	-3.732	0.0	0.0	0.0
164	4	1	21	93 17 3.00	3.0	3.0	0.242	0.0	0.0	0.0
165	4	10	21	90 52 24.30	3.0	3.0	4.346	0.0	0.0	0.0
166	7	19	22	89 48 40.80	3.0	3.0	8.042	0.0	0.0	0.0
167	7	1	22	98 28 30.10	3.0	3.0	4.140	0.0	0.0	0.0
168	7	4	22	88 35 21.70	3.0	3.0	3.905	0.0	0.0	0.0
169	7	10	22	89 58 32.20	3.0	3.0	8.173	0.0	0.0	0.0
170	7	19	23	89 48 41.40	3.0	3.0	8.052	0.0	0.0	0.0
171	7	1	23	98 28 36.30	3.0	3.0	4.150	0.0	0.0	0.0
172	7	4	23	88 35 39.40	3.0	3.0	3.915	0.0	0.0	0.0
173	7	10	23	89 58 21.60	3.0	3.0	8.183	0.0	0.0	0.0
174	4	19	24	89 55 41.50	3.0	3.0	4.224	0.0	0.0	0.0
175	4	7	24	91 26 1.00	3.0	3.0	-3.734	0.0	0.0	0.0
176	4	13	24	89 23 26.80	3.0	3.0	22.134	0.0	0.0	0.0
177	4	10	24	90 52 31.00	3.0	3.0	4.348	0.0	0.0	0.0
178	19	10	26	90 12 22.00	3.0	3.0	0.336	0.0	0.0	0.0

GROUPED VERTICAL ANGLES

	FROM	TO	LIST	OBSERVED	MM	SEC.	H.I.	H.T.	K1	K2
179	19	13	26	89 26 45.10	3.0	3.0	18.111	0.0	0.0	0.0
-179	19	23	26	90 56 13.00	0.0	0.0	18.468	0.0	0.0	0.0
180	19	7	26	90 12 14.40	3.0	3.0	-10.456	0.0	0.0	0.0
181	19	4	26	90 5 17.00	3.0	3.0	-6.638	0.0	0.0	0.0
182	19	13	27	89 27 26.20	3.0	3.0	18.105	0.0	0.0	0.0
183	19	7	27	90 12 23.40	3.0	3.0	-10.463	0.0	0.0	0.0
184	19	4	27	90 5 29.40	3.0	3.0	-6.645	0.0	0.0	0.0
185	19	10	27	90 11 7.00	3.0	3.0	-2.466	0.0	0.0	0.0
-185	19	23	27	90 56 26.30	0.0	0.0	18.505	0.0	0.0	0.0
186	13	10	28	90 53 7.80	10.0	10.0	-20.356	0.0	0.0	0.0
187	13	7	28	90 53 47.50	3.0	3.0	-28.353	0.0	0.0	0.0
188	13	1	28	90 55 57.10	3.0	3.0	-24.611	0.0	0.0	0.0
189	13	19	28	90 49 17.00	3.0	3.0	-20.542	0.0	0.0	0.0
190	13	10	29	90 53 1.50	3.0	3.0	-20.374	0.0	0.0	0.0
191	13	4	29	90 52 41.90	3.0	3.0	-21.882	0.0	0.0	0.0
192	13	7	29	90 53 51.50	3.0	3.0	-28.371	0.0	0.0	0.0
193	13	1	29	90 55 59.50	3.0	3.0	-24.629	0.0	0.0	0.0
194	13	19	29	90 49 23.90	3.0	3.0	-20.560	0.0	0.0	0.0
195	10	19	30	89 50 11.80	3.0	3.0	0.068	0.0	0.0	0.0
196	10	7	30	90 2 56.80	3.0	3.0	-7.890	0.0	0.0	0.0
197	10	4	30	89 9 25.30	10.0	10.0	-3.896	0.0	0.0	0.0
198	10	13	30	89 22 51.70	3.0	3.0	17.978	0.0	0.0	0.0
199	10	13	30	89 22 51.70	10.0	10.0	17.978	0.0	0.0	0.0
200	1	13	99	89 18 44.40	10.0	10.0	22.089	0.0	0.0	0.0
201	4	27	99	79 15 13.30	3.0	3.0	1.321	0.0	0.0	0.0
202	7	13	99	89 21 48.80	10.0	10.0	25.959	0.0	0.0	0.0
-202	23	19	99	89 5 37.10	0.0	0.0	-18.068	0.0	0.0	0.0
203	10	19	99	89 50 20.90	3.0	3.0	0.079	0.0	0.0	0.0
204	12	1	99	77 53 23.70	3.0	3.0	-22.388	0.0	0.0	0.0
205	12	1	99	78 1 0.20	10.0	10.0	-22.350	0.0	0.0	0.0
206	12	1	99	77 59 42.70	10.0	10.0	-22.341	0.0	0.0	0.0
207	11	10	99	89 45 25.10	3.0	3.0	-17.473	0.0	0.0	0.0
208	10	11	99	90 35 3.50	3.0	3.0	17.880	0.0	0.0	0.0
209	4	26	99	88 34 31.20	3.0	3.0	22.463	0.0	0.0	0.0
210	4	25	99	101 27 37.40	3.0	3.0	22.271	0.0	0.0	0.0
211	4	24	99	104 6 19.50	3.0	3.0	22.200	0.0	0.0	0.0

ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	MM	PPM	H.I.	H.T.	
212	1	4	554.3741	5.0	7.00	23.569	23.578	HP 3800 1027
213	1	4	554.3761	5.0	2.00	23.639	23.578	RANGER IV 4021
214	4	1	554.3784	5.0	7.00	23.618	23.624	HP 3800 1027
215	4	1	554.3818	5.0	2.00	23.686	23.624	RANGER IV 4021
216	4	1	554.3787	5.0	7.00	23.622	23.634	HP 3800 1027
217	4	1	554.4075	10.0	2.00	23.685	23.634	RANGER IV 4021
218	1	4	554.3817	5.0	2.00	23.749	23.633	MA 100 497
219	1	4	554.3794	5.0	2.00	23.749	23.633	MA 100 475
220	1	4	554.3762	1.5	2.00	23.749	23.574	MA 100 497
221	1	4	554.3766	1.5	2.00	23.749	23.574	MA 100 475
222	1	4	554.3789	1.5	2.00	23.749	23.578	MA 100 497
223	1	4	554.3811	1.5	2.00	23.749	23.578	MA 100 475
224	4	1	554.4012	1.5	2.00	23.801	23.624	MA 100 475
225	4	1	554.4003	1.5	2.00	23.801	23.624	MA 100 497
226	4	1	554.3954	1.5	2.00	23.796	23.634	MA 100 497
227	4	1	554.3936	1.5	2.00	23.796	23.634	MA 100 475
228	1	7	139.4111	5.0	2.00	23.749	27.361	MA 100 497
229	1	7	139.4146	5.0	2.00	23.749	27.361	MA 100 475
230	1	7	139.4110	5.0	2.00	23.749	27.358	MA 100 475
231	1	7	139.4114	5.0	2.00	23.749	27.358	MA 100 497
232	7	1	139.4812	1.5	2.00	27.616	23.525	MA 100 497
233	7	1	139.4839	1.5	2.00	27.616	23.525	MA 100 475
234	7	1	139.4819	1.5	2.00	27.616	23.528	MA 100 497
235	7	1	139.4825	1.5	2.00	27.616	23.528	MA 100 475
236	1	7	139.4327	5.0	2.00	23.639	27.376	RANGER IV 4021
237	1	7	139.4406	5.0	7.00	23.567	27.401	HP 3800 1027
238	1	7	139.4333	5.0	2.00	23.640	27.381	RANGER IV 4021
239	7	1	139.4700	5.0	2.00	27.506	23.504	RANGER IV 4021
240	7	1	139.4884	5.0	2.00	27.507	23.394	RANGER IV 4021
241	7	1	139.4525	5.0	7.00	27.436	23.522	HP 3800 1027
242	7	1	139.4514	5.0	7.00	27.436	23.520	HP 3800 1027
243	1	7	139.4399	5.0	7.00	23.572	27.398	HP 3800 1027
244	1	12	21.7183	5.0	7.00	23.568	0.488	HP 3800 1027
245	1	12	21.7178	5.0	7.00	23.567	0.488	HP 3800 1027
246	1	12	21.7382	5.0	2.00	23.640	0.464	RANGER IV 4021
247	12	1	21.6749	5.0	2.00	0.604	23.503	RANGER IV 4021
248	12	1	21.7020	5.0	7.00	0.534	23.534	HP 3800 1027
249	1	12	21.7419	5.0	2.00	23.641	0.459	RANGER IV 4021
250	1	12	21.7645	1.5	2.00	23.749	0.490	MA 100 497
251	1	12	21.7647	1.5	2.00	23.749	0.490	MA 100 475
252	1	12	21.7658	1.5	2.00	23.749	0.490	MA 100 497
253	1	12	21.7648	1.5	2.00	23.749	0.490	MA 100 475
254	12	1	21.6592	1.5	2.00	0.712	23.534	MA 100 497
255	12	1	21.6605	1.5	2.00	0.712	23.534	MA 100 475
256	12	1	21.6608	5.0	2.00	0.712	23.534	MA 100 475
257	7	4	454.9098	5.0	2.00	27.507	23.574	RANGER IV 4021
258	7	4	454.9064	5.0	2.00	27.506	23.616	RANGER IV 4021
259	7	4	454.9028	5.0	7.00	27.437	23.574	HP 3800 1027
260	7	4	454.9052	5.0	7.00	27.436	23.578	HP 3800 1027
261	4	7	454.9171	5.0	2.00	23.686	27.397	RANGER IV 4021

ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	MM	PPM	H.I.	H.T.	
262	4	7	454.9033	5.0	7.00	23.618	27.397	HP 3800 1027
263	7	4	454.8962	3.0	2.00	27.616	23.578	MA 100 497
264	7	4	454.9022	1.5	2.00	27.616	23.578	MA 100 475
265	7	4	454.9008	1.5	2.00	27.616	23.676	MA 100 497
266	7	4	454.9009	1.5	2.00	27.616	23.676	MA 100 475
267	4	7	454.9166	1.5	2.00	23.801	27.397	MA 100 497
268	4	7	454.9139	1.5	2.00	23.801	27.397	MA 100 475
269	4	10	699.9964	10.0	7.00	23.618	19.475	HP 3800 1027
270	4	10	700.0073	1.5	2.00	23.686	19.475	RANGER IV 4021
271	4	10	700.0401	10.0	2.00	26.685	19.430	RANGER IV 4021
272	4	10	700.0001	5.0	7.00	23.622	19.415	HP 3800 1027
273	4	10	700.0106	1.5	2.00	23.801	19.435	MA 100 475
274	4	10	700.0066	1.5	2.00	23.801	19.435	MA 100 497
275	4	10	700.0056	1.5	2.00	23.796	19.430	MA 100 497
276	4	10	700.0078	1.5	2.00	23.796	19.430	MA 100 475
277	10	4	700.0077	1.5	2.00	19.640	23.676	MA 100 497
278	10	4	700.0085	1.5	2.00	19.640	23.676	MA 100 475
279	10	4	700.0003	1.5	2.00	19.640	23.675	MA 100 497
280	10	4	700.0030	1.5	2.00	19.640	23.675	MA 100 497
281	11	4	693.3200	5.0	2.00	1.699	23.573	RANGER IV 4021
282	11	4	693.3134	5.0	7.00	1.704	23.573	HP 3800 1027
283	11	4	693.3143	5.0	7.00	1.700	23.583	HP 3800 1027
284	4	11	693.3303	5.0	2.00	23.685	1.694	RANGER IV 4021
285	4	11	693.3161	5.0	7.00	23.622	1.694	HP 3800 1027
286	11	4	693.3176	5.0	1.00	1.699	23.633	MA 100 497
287	11	4	693.3216	5.0	2.00	1.698	23.633	MA 100 475
288	11	4	693.3214	1.5	2.00	1.698	23.583	MA 100 497
289	11	4	693.3211	1.5	2.00	1.698	23.583	MA 100 475
290	4	11	693.3211	1.5	2.00	23.796	1.694	MA 100 497
291	4	11	693.3233	1.5	2.00	23.796	1.694	MA 100 475
292	11	4	693.3188	1.5	2.00	1.697	23.585	MA 100 497
293	11	4	693.3252	1.5	2.00	1.696	23.678	MA 100 475
294	11	4	693.3226	1.5	2.00	1.696	23.678	MA 100 497
295	4	24	88.7859	1.5	2.00	23.796	1.545	MA 100 475
296	4	24	88.7848	1.5	2.00	23.796	1.545	MA 100 497
297	4	25	66.5654	1.5	2.00	23.796	1.195	MA 100 475
298	4	25	66.5649	1.5	2.00	23.796	1.195	MA 100 497
299	4	27	61.6710	5.0	7.00	1.490	0.177	HP 3800 0111
300	7	10	1134.4092	5.0	7.00	27.436	19.431	HP 3800 1027
301	7	10	1134.4145	5.0	7.00	27.437	19.431	HP 3800 1027
302	7	10	1134.4168	5.0	2.00	27.505	19.431	RANGER IV 4021
303	10	7	1134.4097	5.0	7.00	19.462	27.490	HP 3800 1027
304	10	7	1134.4229	5.0	2.00	19.529	27.489	RANGER IV 4021
305	7	10	1134.4197	5.0	2.00	27.507	19.431	RANGER IV 4021
306	7	10	1134.4140	5.0	2.00	27.616	19.449	MA 100 475
307	7	10	1134.4204	5.0	2.00	27.616	19.449	MA 100 475
308	7	10	1134.4106	5.0	2.00	27.616	19.449	MA 100 497
309	7	10	1134.4192	5.0	2.00	27.616	19.449	MA 100 497
310	10	7	1134.4265	3.0	2.00	19.642	27.466	MA 100 475
311	10	7	1134.4233	1.5	2.00	19.642	27.466	MA 100 497

ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	MM	PPM	H.I.	H.T.	
312	7	10	1134.4104	1.5	2.00	27.616	19.490	MA 100 497
313	7	10	1134.4117	1.5	2.00	27.616	19.490	MA 100 475
314	10	7	1134.4198	1.5	2.00	19.640	27.469	MA 100 475
315	10	7	1134.4168	1.5	2.00	19.640	27.469	MA 100 497
316	12	7	148.1357	5.0	2.00	0.604	27.452	RANGER IV 4021
317	12	7	148.1271	9.9	2.00	0.604	27.374	RANGER IV 4021
318	12	7	148.1430	5.0	7.00	0.534	27.452	HP 3800 1027
319	7	12	148.1553	5.0	7.00	27.437	0.490	HP 3800 1027
320	7	12	148.1806	5.0	2.00	27.505	0.465	RANGER IV 4021
321	7	12	148.1564	5.0	7.00	27.437	0.488	HP 3800 1027
322	7	12	148.1831	5.0	2.00	27.507	0.465	RANGER IV 4021
323	12	7	148.1134	1.5	2.00	0.717	27.391	MA 100 475
324	12	7	148.1163	1.5	2.00	0.712	27.452	MA 100 497
325	12	7	148.1181	1.5	2.00	0.712	27.452	MA 100 475
326	7	12	148.1852	1.5	2.00	27.616	0.488	MA 100 475
327	7	12	148.1833	1.5	2.00	27.616	0.488	MA 100 497
328	7	12	148.1841	1.5	2.00	27.616	0.488	MA 100 497
329	7	12	148.1855	1.5	2.00	27.616	0.488	MA 100 475
330	11	10	67.0504	5.0	2.00	1.699	19.395	RANGER IV 4021
331	10	11	67.0404	7.0	5.00	19.462	1.705	HP 3800 1027
332	10	11	67.0456	5.0	2.00	19.529	1.686	RANGER IV 4021
333	11	10	67.0404	7.0	5.00	1.519	19.420	HP 3800 1027
334	11	10	67.0562	5.0	2.00	1.587	19.393	RANGER IV 4021
335	11	10	67.0409	7.0	5.00	1.519	19.415	HP 3800 1027
336	11	10	67.0409	1.5	2.00	1.699	19.420	MA 100 475
337	11	10	67.0403	1.5	2.00	1.699	19.420	MA 100 497
338	10	11	67.0473	1.5	2.00	19.641	1.705	MA 100 475
339	10	11	67.0432	1.5	2.00	19.641	1.705	MA 100 497
340	11	10	67.0418	1.5	2.00	1.698	19.415	MA 100 497
341	11	10	67.0459	1.5	2.00	1.698	19.415	MA 100 475
342	11	10	67.0424	1.5	2.00	1.696	19.415	MA 100 497
343	11	10	67.0426	1.5	2.00	1.697	19.415	MA 100 497
344	11	10	67.0443	1.5	2.00	1.696	19.415	MA 100 475
345	29	10	76.2204	1.5	2.00	1.108	1.355	MA 100 475
346	29	10	76.2195	1.5	2.00	1.108	1.355	MA 100 497
347	10	30	47.9395	1.5	2.00	1.474	1.719	MA 100 475
348	10	30	47.9385	1.5	2.00	1.474	1.719	MA 100 497
349	30	10	47.9454	1.5	2.00	1.954	1.096	MA 100 475
350	30	10	47.9453	1.5	2.00	1.954	1.096	MA 100 497
351	10	31	47.7054	1.5	2.00	1.474	1.545	MA 100 475
352	10	31	47.7067	1.5	2.00	1.474	1.545	MA 100 497
353	10	32	73.8445	5.0	2.00	1.331	1.453	MA 100 497
354	10	32	73.8438	5.0	2.00	1.331	1.453	MA 100 475
355	29	30	45.3156	1.5	2.00	1.108	1.710	MA 100 475
356	29	30	45.3136	1.5	2.00	1.108	1.710	MA 100 497
357	30	29	45.3223	1.5	2.00	1.954	0.873	MA 100 497
358	30	29	45.3254	1.5	2.00	1.954	0.873	MA 100 475
359	29	31	70.0133	1.5	2.00	1.108	1.545	MA 100 497
360	29	31	70.0137	1.5	2.00	1.108	1.545	MA 100 475
361	30	31	24.7598	1.5	2.00	1.954	1.545	MA 100 497

ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	MM	PPM	H.I.	H.T.	
362	30	31	24.7593	1.5	2.00	1.954	1.545	MA 100 475
363	13	1	35100.4144	17.0	1.00	1.660	23.628	GEODIMETER 4 225L10A
364	13	4	35464.4480	17.0	1.00	1.660	26.344	GEODIMETER 4 225L10A
365	13	7	35235.9937	17.0	1.00	1.660	30.190	GEODIMETER 4 225L10A
366	13	10	36022.3258	17.0	1.00	1.660	22.280	GEODIMETER 4 225L10A
367	13	19	37817.8305	17.0	1.00	0.0	0.0	TRANS. FROM TCT
368	19	7	5800.6298	5.0	2.00	19.661	27.466	RANGER IV 4021
369	19	7	5800.6460	30.0	5.00	0.0	0.0	
370	19	10	6355.3250	30.0	5.00	0.0	0.0	
371	33	32	41.3401	1.5	2.00	1.716	1.380	MA 100 497
372	33	30	27.2977	5.0	2.00	1.716	1.685	MA 100 497
373	33	30	27.2985	5.0	2.00	1.716	1.685	MA 100 475
374	33	29	25.6412	1.5	2.00	1.716	0.868	MA 100 475
375	33	29	25.6413	1.5	2.00	1.716	0.868	MA 100 497
376	29	32	39.4635	1.5	2.00	1.108	1.430	MA 100 497
377	29	32	39.4651	1.5	2.00	1.108	1.430	MA 100 475
378	33	31	50.7213	1.5	2.00	1.716	1.560	MA 100 475
379	33	31	50.7223	1.5	2.00	1.716	1.560	MA 100 497
380	33	10	50.7007	1.5	2.00	1.716	1.353	MA 100 497
381	33	10	50.6997	1.5	2.00	1.716	1.353	MA 100 475
382	4	26	52.6113	1.5	2.00	23.796	1.345	MA 100 475
383	4	26	52.6103	1.5	2.00	23.796	1.345	MA 100 497

ELEVATION DIFFERENCES

	FROM	TO	OBSERVED	S.E.	
384	1	7	16.410	0.001	1979 VERT. ADJ.
385	7	4	15.100	0.001	1979 VERT. ADJ.
386	1	12	17.865	0.002	1977 OBS. BY CJF
387	1	12	17.866	0.002	1978 OBS. BY JEP
388	1	39	19.782	0.002	1978 OBS. BY JEP
389	7	12	1.458	0.002	1977 OBS. BY CJF
390	4	29	-6.361	0.001	1979 VERT. ADJ.
391	10	11	17.191	0.001	1979 VERT. ADJ.
392	10	30	-0.096	0.001	1979 VERT. ADJ.
393	29	10	0.045	0.001	1979 VERT. ADJ.
394	30	31	-0.509	0.001	1979 VERT. ADJ.
395	29	30	-0.051	0.001	1979 VERT. ADJ.
396	29	32	0.787	0.001	1979 VERT. ADJ.
397	29	33	0.135	0.001	1979 VERT. ADJ.
-397	1	2	0.554	0.001	1979 VERT. ADJ.
-397	1	3	0.397	0.001	1979 VERT. ADJ.
-397	4	5	-1.240	0.001	1979 VERT. ADJ.
-397	4	6	-0.650	0.001	1979 VERT. ADJ.
-397	7	8	0.079	0.001	1979 VERT. ADJ.
-397	7	9	0.289	0.001	1979 VERT. ADJ.

POSITION DIFFERENCES (METERS)

	FROM	TO	LAT.	S.E.	LON.	S.E.	HEIGHT	S.E.	
398	11	38	0.0	0.0005	0.0	0.0005	7.3000	0.0020	MEAN 1977-1978 OBS.
399	12	39	0.0	0.0005	0.0	0.0005	1.9160	0.0020	1977 OBS. BY CJF

ASTRONOMIC POSITION DIFFERENCES TO BE THE SAME AS GEODETIC

	FROM	TO
400	1	7
401	7	12
402	7	39
403	10	11
404	10	29
405	10	30
406	10	31
407	10	32
408	10	33
409	10	38
410	4	24
411	4	25
412	4	26
413	4	27

A PRIORI STANDARD ERRORS (UNLESS OVERRIDEN BY INPUT ON OBSERVATION CARD)

	VECTOR SUM OF	
DIRECTIONS	0.0 MM	0.0 SEC.
AZIMUTHS	1.0 MM	1.4 SEC.
RECIPROCAL VERTICAL ANGLES	0.0 MM	0.0 SEC.
GROUPED VERTICAL ANGLES	3.0 MM	3.0 SEC.
ABSOLUTE DISTANCES	0.0 MM	0.0 PPM
RELATIVE DISTANCES	0.0 MM	0.0 PPM

APPENDIX B.--OUTPUT DATA FOR ADJUSTMENT

The following computerized listing, using program HAVAGO, shows the output of the three-dimensional adjustment.

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NATIONAL GEODETIC SURVEY, ROCKVILLE, MD       HAVAGO VERSION 79.04.27       MONDAY     SEPTEMBER 10,1979    PAGE   14

JOB STATISTICS

ELLIPSOID:  CLARKE 1866      A = 6378206.400    1/F = 294.9786982

HAYSTACK OBSERVATORY. ADJUSTMENT OF 1977 HAYSTACK VLBI CONTROL SURVEY. FINAL

STANDARD ERROR OF UNIT WEIGHT =  1.25, VARIANCE =  1.55, 300 DEGREES OF FREEDOM.

  444 OBSERVATIONS                                          1 ITERATIONS
   92 DIRECTIONS                                           19 STATIONS
   36 ASTR. AZIMUTHS                                      144 UNKNOWNS
    0 REC. VERTICAL ANGLES                                 23 LISTS OF DIRECTIONS
   83 GROUPED VERTICAL ANGLES                              26 REFRACTION UNKNOWNS
  172 ABSOLUTE DISTANCES                                    0 SCALE UNKNOWNS
    0 RELATIVE DISTANCES
   14 ELEVATION DIFFERENCES
    2 LAT., LON., HEIGHT DIFFERENCES
    0 PLANE DISTANCES
    5 OBSERVED ASTR. LATITUDES
    5 OBSERVED ASTR. LONGITUDES
    1 CONSTRAINED GEOD. LATITUDES
    1 CONSTRAINED GEOD. LONGITUDES
    1 CONSTRAINED GEOD. HEIGHTS
   14 ASTR. POSITION DIFFERENCES

DK/DH ASSUMED AS  -0.010/1000 IF K VALUES NOT INPUT.


SELECTED OPTIONS:

CC  FLAG   OPTION

27   1     MODIFIED GROUPING OF VERTICAL ANGLES
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ADJUSTED DATA: STATIONS

STATION		LATITUDE	SIGMA	LONGITUDE	SIGMA	HEIGHT	SIGMA
1	WESTFORD	42 36 45.82235	0.00050	71 29 38.69778	0.00063	95.642	0.001
4	MILL	42 37 2.89008	0.00049	71 29 31.22928	0.00066	127.156	0.002
7	MICRO	42 36 48.25868	0.00049	71 29 33.62232	0.00064	112.052	0.002
10	HAYSTACK OCP NO 2	42 37 22.74704	0.00049	71 29 16.38475	0.00068	120.846	0.003
11	HAYSTACK TRUNNION	42 37 23.50569	0.00049	71 29 19.14134	0.00068	138.037	0.003
12	WESTFORD ANTENNA	42 36 46.24996	0.00050	71 29 39.41928	0.00064	113.508	0.002
13	WACHUSETT 2 1937	42 29 20.25150	0.00321	71 53 13.98097	0.00191	604.795	1.369
19	TADMUCK MAGS 1936	42 34 35.87200	0.00004	71 26 33.00000	0.00005	141.240	0.041
24	MILLSTONE APCS	42 37 2.73527	0.00049	71 29 27.45751	0.00066	127.723	0.004
25	FIREPOND DMA	42 37 2.86186	0.00050	71 29 34.08856	0.00066	136.215	0.004
26	MILLSTONE N UPPER WALKWAY	42 37 2.50383	0.00049	71 29 28.98168	0.00066	150.928	0.004
27	30078 DMA	42 37 4.08405	0.00051	71 29 29.11887	0.00069	139.977	0.005
29	HAYSTACK OCP NO 3 1975	42 37 21.48265	0.00049	71 29 19.25790	0.00068	120.801	0.003
30	HAYSTACK INTER COMP	42 37 21.34080	0.00049	71 29 17.27894	0.00068	120.750	0.003
31	HAYSTACK INTER COMP RM 1	42 37 21.20666	0.00049	71 29 16.20853	0.00068	120.241	0.003
32	HAYSTACK OCP NO 3 RM 1	42 37 22.73203	0.00049	71 29 19.62484	0.00068	121.588	0.003
33	HAYSTACK OCP NO 3 RM 2	42 37 21.85532	0.00049	71 29 18.25321	0.00068	120.936	0.003
38	HAYSTACK VLBI	42 37 23.50569	0.00049	71 29 19.14134	0.00068	145.337	0.004
39	WESTFORD VLBI	42 36 46.24996	0.00050	71 29 39.41928	0.00064	115.424	0.002

ADJUSTED DATA: DIRECTIONS

	FROM	TO	LIST	OBSERVED	V	N.V	ADJUSTED	DIST.	AZ.	V.A.
1	30	4	1	0 0 0.0	0.18	0.15	0 0 0.0	652.127	209 10 53.44	89 26 22.64
2	30	29	1	66 21 43.31	1.25	0.27	66 21 44.38	45.312	275 32 37.82	89 56 8.31
3	30	10	1	175 58 30.62	-4.59	-1.03	175 58 25.85	47.940	25 9 19.29	89 53 7.89
4	30	31	1	250 26 51.50	3.99	0.47	250 26 55.31	24.748	99 37 48.74	91 10 43.20
5	31	4	1	0 0 0.0	-0.30	-0.24	0 0 0.0	660.823	211 12 13.77	89 24 10.58
6	31	29	1	65 46 57.89	1.54	0.48	65 46 59.72	70.016	276 59 13.50	89 32 31.14
7	31	30	1	68 25 30.12	5.27	0.63	68 25 35.69	24.748	279 37 49.47	88 49 17.60
8	31	10	1	143 58 0.99	-0.67	-0.15	143 58 0.62	47.705	355 10 14.39	89 16 24.92
9	10	19	1	0 0 0.0	0.20	0.29	0 0 0.0	6355.302	144 6 14.42	89 50 39.54
10	10	7	1	56 9 34.94	-0.11	-0.15	56 9 34.62	1134.447	200 15 49.05	90 26 55.70
11	10	4	1	64 48 7.61	0.29	0.38	64 48 7.69	699.953	208 54 22.11	89 29 10.26
12	10	13	1	101 36 55.54	-0.34	-0.49	101 36 55.00	36022.603	245 43 9.42	89 23 30.03
13	10	19	3	0 0 0.0	0.48	0.16	0 0 0.0	6355.302	144 6 14.42	89 50 39.54
14	10	33	3	93 1 26.80	5.10	1.01	93 1 31.41	50.698	237 7 45.83	89 53 54.15
15	10	29	3	95 6 27.70	-1.79	-0.44	95 6 25.43	76.220	239 12 39.85	90 2 2.76
16	10	32	3	125 32 15.60	-2.42	-0.59	125 32 12.70	73.845	269 38 27.12	89 25 28.34
17	10	4	4	0 0 0.0	-0.01	-0.01	0 0 0.0	699.953	208 54 22.11	89 29 10.26
18	10	29	4	30 18 17.03	0.70	0.25	30 18 17.73	76.220	239 12 39.85	90 2 2.76
19	10	31	4	326 15 54.48	-2.33	-0.53	326 15 52.16	47.705	175 10 14.27	90 43 36.62
20	10	30	4	356 14 56.92	0.85	0.20	356 14 57.78	47.940	205 9 19.89	90 6 53.67
21	10	7	5	0 0 0.0	0.19	0.16	0 0 0.0	1134.447	200 15 49.05	90 26 55.70
22	10	4	5	8 38 33.46	-0.20	-0.16	8 38 33.07	699.953	208 54 22.11	89 29 10.26
23	29	4	1	0 0 0.0	0.05	0.04	0 0 0.0	635.317	205 26 5.04	89 25 45.29
24	29	32	1	142 19 35.00	2.62	0.44	142 19 37.57	39.457	347 45 42.61	88 51 26.27
25	29	10	1	213 46 33.78	-0.86	-0.29	213 46 32.86	76.220	59 12 37.90	89 57 59.71
26	29	33	1	217 53 49.20	1.66	0.19	217 53 50.80	25.622	63 19 55.84	89 41 53.39
27	29	30	1	250 6 33.10	-1.61	-0.34	250 6 31.44	45.312	95 32 36.48	90 3 53.15
28	29	31	1	251 33 6.02	0.43	0.13	251 33 6.40	70.016	96 59 11.43	90 27 31.12
29	11	4	1	0 0 0.0	0.05	0.06	0 0 0.0	693.317	203 25 0.12	90 54 6.89
30	11	10	1	267 1 15.42	-0.80	-0.26	267 1 14.57	69.210	110 26 14.70	104 22 57.05
31	7	19	1	0 0 0.0	0.32	0.46	0 0 0.0	5800.644	134 45 7.65	89 44 14.92
32	7	1	1	102 13 48.65	-0.37	-0.22	102 13 47.96	138.939	236 58 55.61	96 46 59.78
33	7	12	1	110 6 55.80	3.78	2.40	110 6 59.26	145.953	244 52 6.91	89 25 43.87
34	7	4	1	232 8 11.85	-2.50	-3.00	232 8 9.02	455.017	6 53 16.67	88 6 1.30
35	7	10	1	245 30 28.61	0.81	1.12	245 30 29.10	1134.447	20 15 36.75	89 33 41.63
36	7	19	3	0 0 0.0	0.58	0.83	0 0 0.0	5800.644	134 45 7.65	89 44 14.92
37	7	1	3	102 13 57.14	-8.60	-2.57	102 13 47.96	138.939	236 58 55.61	96 46 59.78
38	7	12	3	110 7 4.38	-4.54	-1.37	110 6 59.26	145.953	244 52 6.91	89 25 43.87
39	7	4	3	232 8 10.91	-1.31	-1.57	232 8 9.02	455.017	6 53 16.67	88 6 1.30
40	7	10	3	245 30 28.70	0.98	1.36	245 30 29.10	1134.447	20 15 36.75	89 33 41.63
41	7	19	9	0 0 0.0	-0.30	-0.42	0 0 0.0	5800.644	134 45 7.65	89 44 14.92

ADJUSTED DATA: DIRECTIONS

	FROM	TO	LIST	OBSERVED	V	N.V	ADJUSTED	DIST.	AZ.	V.A.	
42	7	1	9	102 13 52.20	-4.54	-2.46	102 13 47.96	138.939	236 58 55.61	96 46 59.78	
43	7	12	9	110 7 0.09	-1.13	-0.61	110 6 59.26	145.953	244 52 6.91	89 25 43.87	
44	7	13	9	112 16 44.53	-1.56	-2.23	112 16 43.27	35236.277	247 1 50.92	89 21 23.23	
45	7	10	9	245 30 25.95	2.85	3.94	245 30 29.10	1134.447	20 15 36.75	89 33 41.63	
46	4	19	1	0 0 0.0	0.52	0.74	0 0 0.0	6090.317	138 7 55.59	89 53 40.58	
47	4	7	1	48 45 22.17	0.97	1.16	48 45 22.62	455.017	186 53 18.21	91 54 13.54	
48	4	1	1	59 46 47.35	0.65	0.82	59 46 47.48	554.384	197 54 43.07	93 15 38.52	
49	4	11	1	245 16 56.69	-0.53	-0.70	245 16 55.64	693.317	23 24 51.23	89 6 16.09	
50	4	10	1	250 46 17.74	-1.47	-1.94	250 46 15.75	699.953	28 54 11.34	90 31 12.99	
51	4	19	8	0 0 0.0	-0.60	-0.85	0 0 0.0	6090.317	138 7 55.59	89 53 40.58	
52	4	7	8	48 45 21.48	0.54	0.65	48 45 22.62	455.017	186 53 18.21	91 54 13.54	
53	4	13	8	108 15 41.79	0.27	0.39	108 15 42.66	35464.692	246 23 38.25	89 23 13.32	
54	4	10	8	250 46 15.22	-0.07	-0.09	250 46 15.75	699.953	28 54 11.34	90 31 12.99	
55	4	27	8	274 24 57.69	-0.00	-0.00	274 24 58.29	61.929	52 32 53.88	78 3 10.63	TRANS. FROM COMB.LST
56	4	10	10	0 0 0.0	-0.77	-1.01	0 0 0.0	699.953	28 54 11.34	90 31 12.99	
57	4	7	10	157 59 5.17	0.93	1.11	157 59 6.87	455.017	186 53 18.21	91 54 13.54	
58	4	10	14	0 0 0.0	0.97	0.79	0 0 0.0	699.953	28 54 11.34	90 31 12.99	
59	4	24	14	64 16 37.96	-0.00	-0.00	64 16 36.99	86.098	93 10 48.33	89 37 25.70	
60	4	26	14	74 11 39.28	-0.00	-0.00	74 11 38.31	57.717	103 5 49.65	65 40 42.62	
61	4	1	14	169 0 33.71	-1.01	-0.80	169 0 31.73	554.384	197 54 43.07	93 15 38.52	
62	4	25	14	240 19 53.89	0.00	0.00	240 19 52.92	65.799	269 14 4.26	82 5 14.16	
63	19	13	1	0 0 0.0	2.20	3.15	0 0 0.0	37817.800	255 13 30.49	89 28 0.63	
64	19	7	1	59 33 42.50	-1.39	-1.98	59 33 38.91	5800.644	314 47 9.40	90 18 52.25	
65	19	4	1	62 56 28.09	-0.56	-0.80	62 56 25.32	6090.317	318 9 55.82	90 9 36.17	
66	19	10	1	68 54 35.85	-0.26	-0.36	68 54 33.39	6355.302	324 8 3.89	90 12 45.64	
67	19	13	2	0 0 0.0	-0.25	-0.36	0 0 0.0	37817.800	255 13 30.49	89 28 0.63	
68	19	7	2	59 33 38.22	0.44	0.62	59 33 38.91	5800.644	314 47 9.40	90 18 52.25	
69	19	4	2	62 56 24.69	0.38	0.54	62 56 25.32	6090.317	318 9 55.82	90 9 36.17	
70	19	10	2	68 54 33.70	-0.56	-0.80	68 54 33.39	6355.302	324 8 3.89	90 12 45.64	
71	19	13	3	0 0 0.0	-0.88	-1.26	0 0 0.0	37817.800	255 13 30.49	89 28 0.63	
72	19	7	3	59 33 37.20	0.83	1.18	59 33 38.91	5800.644	314 47 9.40	90 18 52.25	
73	19	4	3	62 56 24.37	0.07	0.10	62 56 25.32	6090.317	318 9 55.82	90 9 36.17	
74	19	10	3	68 54 32.53	-0.02	-0.03	68 54 33.39	6355.302	324 8 3.89	90 12 45.64	
75	13	10	1	0 0 0.0	-0.91	-1.30	0 0 0.0	36022.603	65 27 0.72	90 55 50.60	
76	13	7	1	1 18 52.21	0.76	1.08	1 18 53.87	35236.277	66 45 54.59	90 57 31.10	
77	13	1	1	1 21 14.17	0.28	0.40	1 21 15.36	35100.633	66 48 16.07	90 59 16.49	
78	13	19	1	9 28 31.38	-0.13	-0.19	9 28 32.16	37817.800	74 55 32.87	90 52 15.94	
79	13	10	2	0 0 0.0	-0.17	-0.24	0 0 0.0	36022.603	65 27 0.72	90 55 50.60	
80	13	4	2	0 40 39.51	-0.04	-0.06	0 40 39.63	35464.692	66 7 40.35	90 55 48.41	
81	13	7	2	1 18 53.01	0.69	0.99	1 18 53.87	35236.277	66 45 54.59	90 57 31.10	
82	13	1	2	1 21 15.09	0.10	0.14	1 21 15.36	35100.633	66 48 16.07	90 59 16.49	

ADJUSTED DATA: DIRECTIONS

	FROM	TO	LIST	OBSERVED	V	N.V	ADJUSTED	DIST.	AZ.	V.A.
83	13	19	2	9 28 32.57	-0.58	-0.83	9 28 32.16	37817.800	74 55 32.87	90 52 15.94
84	13	10	3	0 0 0.0	0.10	0.15	0 0 0.0	36022.603	65 27 0.72	90 55 50.60
85	13	4	3	0 40 39.98	-0.24	-0.35	0 40 39.63	35464.692	66 7 40.35	90 55 48.41
86	13	19	3	9 28 32.12	0.14	0.20	9 28 32.16	37817.800	74 55 32.87	90 52 15.94
87	1	13	1	0 0 0.0	0.68	0.97	0 0 0.0	35100.633	247 4 8.96	89 19 33.44
88	1	4	1	130 50 30.80	-0.99	-1.25	130 50 29.13	554.384	17 54 38.08	86 44 39.50
89	1	7	1	169 54 43.39	0.50	0.30	169 54 43.21	138.939	56 58 52.16	83 13 4.69
90	1	4	2	0 0 0.0	-0.33	-0.11	0 0 0.0	554.384	17 54 38.08	86 44 39.50
91	1	7	2	39 4 17.07	-3.32	-0.99	39 4 14.08	138.939	56 58 52.16	83 13 4.69
92	1	12	2	290 49 33.07	21.53	2.68	290 49 54.93	27.636	308 44 33.01	49 43 27.56

ADJUSTED DATA: ASTRONOMIC AZIMUTHS

	FROM	TO	OBSERVED	V	N.V	ADJUSTED	DIST.	V.A.	
93	4	1	197 54 42.89	0.18	0.12	197 54 43.07	554.384	93 15 38.52	77 09 27 CWW
94	4	1	197 54 39.98	3.09	2.13	197 54 43.07	554.384	93 15 38.52	77 10 05 DJN
95	4	1	197 54 44.17	-1.10	-0.76	197 54 43.07	554.384	93 15 38.52	77 10 24 DJN
96	4	7	186 53 17.42	0.79	0.54	186 53 18.21	455.017	91 54 13.54	77 09 28 DJN
97	4	7	186 53 18.36	-0.15	-0.10	186 53 18.21	455.017	91 54 13.54	77 09 29 CWW
98	4	7	186 53 15.43	2.78	1.89	186 53 18.21	455.017	91 54 13.54	77 10 22 CWW
99	4	7	186 53 20.41	-2.20	-1.50	186 53 18.21	455.017	91 54 13.54	77 10 23 DJN
100	4	10	28 54 10.40	0.94	0.66	28 54 11.34	699.953	90 31 12.99	77 09 28 DJN
101	4	10	28 54 12.33	-0.99	-0.69	28 54 11.34	699.953	90 31 12.99	77 09 29 CWW
102	4	10	28 54 10.15	1.19	0.83	28 54 11.34	699.953	90 31 12.99	77 10 22 CWW
103	4	10	28 54 12.44	-1.10	-0.77	28 54 11.34	699.953	90 31 12.99	77 10 23 DJN
104	4	11	23 24 48.50	2.73	1.91	23 24 51.23	693.317	89 6 16.09	77 09 28 CWW
105	4	11	23 24 51.18	0.05	0.04	23 24 51.23	693.317	89 6 16.09	77 10 05 DJN
106	4	11	23 24 51.89	-0.66	-0.46	23 24 51.23	693.317	89 6 16.09	77 10 24 DJN
107	7	4	6 53 16.27	0.40	0.27	6 53 16.67	455.017	88 6 1.30	77 10 06 DJN
108	7	4	6 53 16.57	0.10	0.07	6 53 16.67	455.017	88 6 1.30	77 10 06 CWW
109	7	4	6 53 19.09	-2.42	-1.64	6 53 16.67	455.017	88 6 1.30	77 10 07 DJN
110	7	4	6 53 15.13	1.54	1.05	6 53 16.67	455.017	88 6 1.30	77 10 08 CWW
111	7	10	20 15 37.28	-0.53	-0.38	20 15 36.75	1134.447	89 33 41.63	77 10 06 DJN
112	7	10	20 15 36.66	0.09	0.06	20 15 36.75	1134.447	89 33 41.63	77 10 07 CWW
113	7	10	20 15 40.57	-3.82	-2.71	20 15 36.75	1134.447	89 33 41.63	77 10 07 DJN
114	7	10	20 15 35.43	1.32	0.93	20 15 36.75	1134.447	89 33 41.63	77 10 08 CWW
115	10	4	208 54 23.78	-1.67	-1.17	208 54 22.11	699.953	89 29 10.26	77 09 30 DJN
116	10	4	208 54 22.70	-0.59	-0.41	208 54 22.11	699.953	89 29 10.26	77 10 11 DJN
117	10	4	208 54 23.31	-1.20	-0.84	208 54 22.11	699.953	89 29 10.26	77 10 22 CWW
118	10	4	208 54 22.61	-0.50	-0.35	208 54 22.11	699.953	89 29 10.26	77 10 22 DJN
119	10	4	208 54 22.80	-0.69	-0.48	208 54 22.11	699.953	89 29 10.26	77 10 22 CWW
120	10	4	208 54 20.47	1.64	1.07	208 54 22.11	699.953	89 29 10.26	77 10 12 CWW
121	10	7	200 15 50.44	-1.39	-0.99	200 15 49.05	1134.447	90 26 55.70	77 09 30 DJN
122	10	7	200 15 48.56	0.49	0.34	200 15 49.05	1134.447	90 26 55.70	77 10 11 DJN
123	10	7	200 15 50.49	-1.44	-1.02	200 15 49.05	1134.447	90 26 55.70	77 10 22 CWW
124	10	7	200 15 48.01	1.04	0.69	200 15 49.05	1134.447	90 26 55.70	77 10 23 CWW
125	10	7	200 15 47.53	1.52	1.07	200 15 49.05	1134.447	90 26 55.70	77 10 23 CWW
126	10	7	200 15 48.98	0.07	0.05	200 15 49.05	1134.447	90 26 55.70	77 10 12 DJN
127	10	11	290 26 15.67	0.89	0.27	290 26 16.56	69.210	75 37 5.11	77 10 22 CWW
128	13	19	74 55 32.06	0.81	0.58	74 55 32.87	37817.800	90 52 15.94	73 10 1,9,11 VAR.

ADJUSTED DATA: GROUPED VERTICAL ANGLES

	FROM	TO	LIST	OBSERVED	REF/KM	V	N.V	ADJUSTED	DIST.	AZ.
129	4	1	1	93 15 32.57	-2.62	7.41	2.31	93 15 38.52	554.384	197 54 43.07
130	4	11	1	89 6 23.57	-2.62	-5.66	-1.81	89 6 16.09	693.317	23 24 51.23
131	4	1	2	93 15 33.35	7.32	1.12	0.35	93 15 38.52	554.384	197 54 43.07
132	4	11	2	89 6 11.87	7.32	-0.85	-0.27	89 6 16.09	693.317	23 24 51.23
133	4	1	3	93 15 31.25	10.82	1.28	0.40	93 15 38.52	554.384	197 54 43.07
134	4	11	3	89 6 9.57	10.82	-0.98	-0.31	89 6 16.09	693.317	23 24 51.23
135	4	1	4	93 15 26.37	13.47	4.70	1.47	93 15 38.52	554.384	197 54 43.07
136	4	11	4	89 6 10.34	13.47	-3.59	-1.15	89 6 16.09	693.317	23 24 51.23
137	4	7	5	91 54 11.11	5.08	0.13	0.04	91 54 13.54	455.017	186 53 18.21
138	4	10	5	90 31 9.51	5.08	-0.07	-0.02	90 31 12.99	699.953	28 54 11.34
139	4	7	6	91 54 11.51	4.42	0.02	0.01	91 54 13.54	455.017	186 53 18.21
140	4	10	6	90 31 9.91	4.42	-0.01	-0.00	90 31 12.99	699.953	28 54 11.34
141	4	7	9	91 54 15.98	8.26	-6.19	-1.88	91 54 13.54	455.017	186 53 18.21
142	4	10	9	90 31 3.58	8.26	3.63	1.16	90 31 12.99	699.953	28 54 11.34
143	7	4	10	88 5 57.76	9.16	-0.63	-0.19	88 6 1.30	455.017	6 53 16.67
144	7	10	10	89 33 31.02	9.16	0.21	0.07	89 33 41.63	1134.447	20 15 36.75
145	7	4	11	88 5 57.96	7.09	0.11	0.03	88 6 1.30	455.017	6 53 16.67
146	7	10	11	89 33 33.62	7.09	-0.04	-0.01	89 33 41.63	1134.447	20 15 36.75
147	7	4	12	88 5 57.76	6.76	0.47	0.14	88 6 1.30	455.017	6 53 16.67
148	7	10	12	89 33 34.12	6.76	-0.16	-0.05	89 33 41.63	1134.447	20 15 36.75
149	7	4	13	88 5 55.96	9.33	1.10	0.33	88 6 1.30	455.017	6 53 16.67
150	7	10	13	89 33 31.42	9.33	-0.38	-0.12	89 33 41.63	1134.447	20 15 36.75
151	10	7	14	90 26 52.21	2.29	0.88	0.29	90 26 55.70	1134.447	200 15 49.05
152	10	4	14	89 29 10.16	2.29	-1.51	-0.48	89 29 10.26	699.953	208 54 22.11
153	10	7	16	90 26 49.83	3.91	1.43	0.47	90 26 55.70	1134.447	200 15 49.05
154	10	4	16	89 29 9.95	3.91	-2.43	-0.78	89 29 10.26	699.953	208 54 22.11
155	10	7	18	90 26 52.63	0.81	2.15	0.70	90 26 55.70	1134.447	200 15 49.05
156	10	4	18	89 29 13.35	0.81	-3.66	-1.17	89 29 10.26	699.953	208 54 22.11
157	1	4	19	86 44 47.77	-16.49	0.86	0.27	86 44 39.50	554.384	17 54 38.08
158	1	7	19	83 13 16.53	-16.49	-9.57	-1.79	83 13 4.69	138.939	56 58 52.16
159	1	12	19	49 43 40.09	-16.49	-12.18	-0.42	49 43 27.56	27.636	308 44 33.01
160	1	4	20	86 44 28.27	20.69	-0.22	-0.07	86 44 39.50	554.384	17 54 38.08
161	1	7	20	83 12 34.64	20.69	27.20	1.52	83 13 4.69	138.939	56 58 52.16
162	4	19	21	89 52 48.01	8.74	-0.66	-0.22	89 53 40.58	6090.317	138 7 55.59

ADJUSTED DATA: GROUPED VERTICAL ANGLES

	FROM	TO	LIST	OBSERVED	REF/KM	V	N.V	ADJUSTED	DIST.	AZ.
163	4	7	21	91 54 4.95	8.74	4.62	1.40	91 54 13.54	455.017	186 53 18.21
164	4	1	21	93 15 33.11	8.74	0.58	0.18	93 15 38.52	554.384	197 54 43.07
165	4	10	21	90 31 3.75	8.74	3.12	1.00	90 31 12.99	699.953	28 54 11.34
166	7	19	22	89 43 54.83	3.27	1.14	0.38	89 44 14.92	5800.644	134 45 7.65
167	7	1	22	96 47 10.16	3.27	-10.82	-2.02	96 46 59.78	138.939	236 58 55.61
168	7	4	22	88 5 52.03	3.27	7.79	2.36	88 6 1.30	455.017	6 53 16.67
169	7	10	22	89 33 46.17	3.27	-8.25	-2.71	89 33 41.63	1134.447	20 15 36.75
170	7	19	23	89 43 55.08	3.48	-0.37	-0.12	89 44 14.92	5800.644	134 45 7.65
171	7	1	23	96 47 1.73	3.48	-2.43	-0.45	96 46 59.78	138.939	236 58 55.61
172	7	4	23	88 6 5.20	3.48	-5.48	-1.66	88 6 1.30	455.017	6 53 16.67
173	7	10	23	89 33 33.76	3.48	3.92	1.28	89 33 41.63	1134.447	20 15 36.75
174	4	19	24	89 53 18.44	3.27	2.20	0.73	89 53 40.58	6090.317	138 7 55.59
175	4	7	24	91 54 13.16	3.27	-1.10	-0.33	91 54 13.54	455.017	186 53 18.21
176	4	13	24	89 21 17.62	3.27	-0.38	-0.13	89 23 13.32	35464.692	246 23 38.25
177	4	10	24	90 31 9.86	3.27	0.84	0.27	90 31 12.99	699.953	28 54 11.34
178	19	10	26	90 12 11.10	4.66	4.90	1.63	90 12 45.64	6355.302	324 8 3.89
179	19	13	26	89 25 5.85	4.66	-1.62	-0.54	89 28 0.63	37817.800	255 13 30.49
180	19	7	26	90 18 26.21	4.66	-1.01	-0.34	90 18 52.25	5800.644	314 47 9.40
181	19	4	26	90 9 1.82	4.66	5.95	1.98	90 9 36.17	6090.317	318 9 55.82
182	19	13	27	89 25 46.98	3.51	1.10	0.37	89 28 0.63	37817.800	255 13 30.49
183	19	7	27	90 18 35.46	3.51	-3.53	-1.18	90 18 52.25	5800.644	314 47 9.40
184	19	4	27	90 9 14.45	3.51	0.37	0.12	90 9 36.17	6090.317	318 9 55.82
185	19	10	27	90 12 27.04	3.51	-3.67	-1.22	90 12 45.64	6355.302	324 8 3.89
186	13	10	28	90 55 4.81	1.64	-13.18	-1.32	90 55 50.60	36022.603	65 27 0.72
187	13	7	28	90 56 33.92	1.64	-0.51	-0.17	90 57 31.10	35236.277	66 45 54.59
188	13	1	28	90 58 22.19	1.64	-3.16	-1.05	90 59 16.49	35100.633	66 48 16.07
189	13	19	28	90 51 9.50	1.64	4.53	1.51	90 52 15.94	37817.800	74 55 32.87
190	13	10	29	90 54 58.62	1.53	-3.20	-1.07	90 55 50.60	36022.603	65 27 0.72
191	13	4	29	90 54 49.61	1.53	4.48	1.49	90 55 48.41	35464.692	66 7 40.35
192	13	7	29	90 56 38.02	1.53	-0.90	-0.30	90 57 31.10	35236.277	66 45 54.59
193	13	1	29	90 58 24.69	1.53	-1.97	-0.66	90 59 16.49	35100.633	66 48 16.07
194	13	19	29	90 51 16.50	1.53	1.52	0.51	90 52 15.94	37817.800	74 55 32.87
195	10	19	30	89 50 9.59	3.96	4.79	1.60	89 50 39.54	6355.302	144 6 14.42
196	10	7	30	90 26 51.37	3.96	-0.16	-0.05	90 26 55.70	1134.447	200 15 49.05
197	10	4	30	89 28 33.27	3.96	34.22	3.28	89 29 10.26	699.953	208 54 22.11
198	10	13	30	89 21 8.29	3.96	-0.82	-0.27	89 23 30.03	36022.603	245 43 9.42
199	10	13	30	89 21 8.29	3.96	-0.82	-0.08	89 23 30.03	36022.603	245 43 9.42
200	1	13	99	89 16 34.12	4.20	32.03	3.20	89 19 33.44	35100.633	247 4 8.96
201	4	27	99	78 3 10.37	4.20	0.00	0.00	78 3 10.63	61.929	52 32 53.88
202	7	13	99	89 19 16.38	4.20	-21.01	-2.10	89 21 23.23	35236.277	247 1 50.92
203	10	19	99	89 50 18.33	4.20	-5.47	-1.82	89 50 39.54	6355.302	144 6 14.42

ADJUSTED DATA: GROUPED VERTICAL ANGLES

	FROM	TO	LIST	OBSERVED	REF/KM	V	N.V	ADJUSTED	DIST.	AZ.
204	12	1	99	130 16 17.08	4.20	15.95	0.55	130 16 33.12	27.636	128 44 32.52
205	12	1	99	130 17 58.05	4.20	-85.02	-0.88	130 16 33.12	27.636	128 44 32.52
206	12	1	99	130 15 16.31	4.20	76.72	0.80	130 16 33.12	27.636	128 44 32.52
207	11	10	99	104 22 48.81	4.20	7.96	0.82	104 22 57.05	69.210	110 26 14.70
208	10	11	99	75 36 47.65	4.20	17.19	1.77	75 37 5.11	69.210	290 26 16.56
209	4	26	99	65 40 42.40	4.20	0.00	0.00	65 40 42.62	57.717	103 5 49.65
210	4	25	99	82 5 13.89	4.20	0.00	0.00	82 5 14.16	65.799	269 14 4.26
211	4	24	99	89 37 25.34	4.20	-0.00	-0.00	89 37 25.70	86.098	93 10 48.33

ADJUSTED DATA: ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	V	N.V	ADJUSTED	AZ.	V.A	
212	1	4	554.3715	0.0127	2.00	554.3842	17 54 38.08	86 44 39.50	HP 3800 1027
213	1	4	554.3775	0.0067	1.30	554.3842	17 54 38.08	86 44 39.50	RANGER IV 4021
214	4	1	554.3767	0.0075	1.19	554.3842	197 54 43.07	93 15 38.52	HP 3800 1027
215	4	1	554.3762	0.0080	1.56	554.3842	197 54 43.07	93 15 38.52	RANGER IV 4021
216	4	1	554.3773	0.0069	1.08	554.3842	197 54 43.07	93 15 38.52	HP 3800 1027
217	4	1	554.4025	-0.0184	-1.82	554.3842	197 54 43.07	93 15 38.52	RANGER IV 4021
218	1	4	554.3862	-0.0020	-0.40	554.3842	17 54 38.08	86 44 39.50	MA 100 497
219	1	4	554.3839	0.0003	0.05	554.3842	17 54 38.08	86 44 39.50	MA 100 475
220	1	4	554.3841	0.0001	0.07	554.3842	17 54 38.08	86 44 39.50	MA 100 497
221	1	4	554.3845	-0.0003	-0.15	554.3842	17 54 38.08	86 44 39.50	MA 100 475
222	1	4	554.3865	-0.0023	-1.26	554.3842	17 54 38.08	86 44 39.50	MA 100 497
223	1	4	554.3887	-0.0045	-2.44	554.3842	17 54 38.08	86 44 39.50	MA 100 475
224	4	1	554.3891	-0.0049	-2.60	554.3842	197 54 43.07	93 15 38.52	MA 100 475
225	4	1	554.3882	-0.0040	-2.12	554.3842	197 54 43.07	93 15 38.52	MA 100 497
226	4	1	554.3841	0.0001	0.05	554.3842	197 54 43.07	93 15 38.52	MA 100 497
227	4	1	554.3823	0.0019	1.01	554.3842	197 54 43.07	93 15 38.52	MA 100 475
228	1	7	138.9378	0.0009	0.18	138.9387	56 58 52.16	83 13 4.69	MA 100 497
229	1	7	138.9413	-0.0026	-0.52	138.9387	56 58 52.16	83 13 4.69	MA 100 475
230	1	7	138.9381	0.0006	0.11	138.9387	56 58 52.16	83 13 4.69	MA 100 475
231	1	7	138.9385	0.0002	0.03	138.9387	56 58 52.16	83 13 4.69	MA 100 497
232	7	1	138.9383	0.0004	0.25	138.9387	236 58 55.61	96 46 59.78	MA 100 497
233	7	1	138.9410	-0.0023	-1.52	138.9387	236 58 55.61	96 46 59.78	MA 100 475
234	7	1	138.9394	-0.0008	-0.50	138.9387	236 58 55.61	96 46 59.78	MA 100 497
235	7	1	138.9400	-0.0014	-0.89	138.9387	236 58 55.61	96 46 59.78	MA 100 475
236	1	7	138.9414	-0.0027	-0.54	138.9387	56 58 52.16	83 13 4.69	RANGER IV 4021
237	1	7	138.9352	0.0034	0.67	138.9387	56 58 52.16	83 13 4.69	HP 3800 1027
238	1	7	138.9414	-0.0027	-0.55	138.9387	56 58 52.16	83 13 4.69	RANGER IV 4021
239	7	1	138.9401	-0.0015	-0.29	138.9387	236 58 55.61	96 46 59.78	RANGER IV 4021
240	7	1	138.9423	-0.0036	-0.72	138.9387	236 58 55.61	96 46 59.78	RANGER IV 4021
241	7	1	138.9355	0.0032	0.62	138.9387	236 58 55.61	96 46 59.78	HP 3800 1027
242	7	1	138.9341	0.0046	0.90	138.9387	236 58 55.61	96 46 59.78	HP 3800 1027
243	1	7	138.9357	0.0030	0.58	138.9387	56 58 52.16	83 13 4.69	HP 3800 1027
244	1	12	27.6345	0.0014	0.28	27.6359	308 44 33.01	49 43 27.56	HP 3800 1027
245	1	12	27.6342	0.0017	0.33	27.6359	308 44 33.01	49 43 27.56	HP 3800 1027
246	1	12	27.6311	0.0048	0.95	27.6359	308 44 33.01	49 43 27.56	RANGER IV 4021
247	12	1	27.6338	0.0021	0.41	27.6359	128 44 32.52	130 16 33.12	RANGER IV 4021
248	12	1	27.6372	-0.0014	-0.27	27.6359	128 44 32.52	130 16 33.12	HP 3800 1027
249	1	12	27.6334	0.0025	0.50	27.6359	308 44 33.01	49 43 27.56	RANGER IV 4021
250	1	12	27.6370	-0.0011	-0.75	27.6359	308 44 33.01	49 43 27.56	MA 100 497
251	1	12	27.6372	-0.0013	-0.88	27.6359	308 44 33.01	49 43 27.56	MA 100 475
252	1	12	27.6383	-0.0024	-1.62	27.6359	308 44 33.01	49 43 27.56	MA 100 497
253	1	12	27.6373	-0.0014	-0.95	27.6359	308 44 33.01	49 43 27.56	MA 100 475
254	12	1	27.6359	0.0000	0.01	27.6359	128 44 32.52	130 16 33.12	MA 100 497
255	12	1	27.6372	-0.0013	-0.85	27.6359	128 44 32.52	130 16 33.12	MA 100 475
256	12	1	27.6375	-0.0016	-0.32	27.6359	128 44 32.52	130 16 33.12	MA 100 475
257	7	4	455.0215	-0.0043	-0.84	455.0173	6 53 16.67	88 6 1.30	RANGER IV 4021
258	7	4	455.0171	0.0002	0.04	455.0173	6 53 16.67	88 6 1.30	RANGER IV 4021
259	7	4	455.0128	0.0045	0.75	455.0173	6 53 16.67	88 6 1.30	HP 3800 1027
260	7	4	455.0151	0.0022	0.37	455.0173	6 53 16.67	88 6 1.30	HP 3800 1027
261	4	7	455.0233	-0.0060	-1.19	455.0173	186 53 18.21	91 54 13.54	RANGER IV 4021

ADJUSTED DATA: ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	V	N.V	ADJUSTED	AZ.	V.A	
262	4	7	455.0112	0.0061	1.02	455.0173	186 53 18.21	91 54 13.54	HP 3800 1027
263	7	4	455.0105	0.0068	2.16	455.0173	6 53 16.67	88 6 1.30	MA 100 497
264	7	4	455.0165	0.0008	0.45	455.0173	6 53 16.67	88 6 1.30	MA 100 475
265	7	4	455.0127	0.0046	2.61	455.0173	6 53 16.67	88 6 1.30	MA 100 497
266	7	4	455.0128	0.0045	2.56	455.0173	6 53 16.67	88 6 1.30	MA 100 475
267	4	7	455.0199	-0.0026	-1.51	455.0173	186 53 18.21	91 54 13.54	MA 100 497
268	4	7	455.0172	0.0001	0.03	455.0173	186 53 18.21	91 54 13.54	MA 100 475
269	4	10	699.9444	0.0087	0.78	699.9531	28 54 11.34	90 31 12.99	HP 3800 1027
270	4	10	699.9543	-0.0012	-0.59	699.9531	28 54 11.34	90 31 12.99	RANGER IV 4021
271	4	10	699.9346	0.0185	1.83	699.9531	28 54 11.34	90 31 12.99	RANGER IV 4021
272	4	10	699.9472	0.0059	0.85	699.9531	28 54 11.34	90 31 12.99	HP 3800 1027
273	4	10	699.9552	-0.0022	-1.05	699.9531	28 54 11.34	90 31 12.99	MA 100 475
274	4	10	699.9512	0.0018	0.90	699.9531	28 54 11.34	90 31 12.99	MA 100 497
275	4	10	699.9502	0.0028	1.39	699.9531	28 54 11.34	90 31 12.99	MA 100 497
276	4	10	699.9524	0.0006	0.31	699.9531	28 54 11.34	90 31 12.99	MA 100 475
277	10	4	699.9573	-0.0042	-2.05	699.9531	208 54 22.11	89 29 10.26	MA 100 497
278	10	4	699.9581	-0.0050	-2.44	699.9531	208 54 22.11	89 29 10.26	MA 100 475
279	10	4	699.9499	0.0032	1.55	699.9531	208 54 22.11	89 29 10.26	MA 100 497
280	10	4	699.9526	0.0005	0.23	699.9531	208 54 22.11	89 29 10.26	MA 100 497
281	11	4	693.3169	0.0002	0.04	693.3170	203 25 0.12	90 54 6.89	RANGER IV 4021
282	11	4	693.3103	0.0067	0.96	693.3170	203 25 0.12	90 54 6.89	HP 3800 1027
283	11	4	693.3110	0.0060	0.87	693.3170	203 25 0.12	90 54 6.89	HP 3800 1027
284	4	11	693.3253	-0.0082	-1.59	693.3170	23 24 51.23	89 6 16.09	RANGER IV 4021
285	4	11	693.3121	0.0050	0.71	693.3170	23 24 51.23	89 6 16.09	HP 3800 1027
286	11	4	693.3135	0.0036	0.70	693.3170	203 25 0.12	90 54 6.89	MA 100 497
287	11	4	693.3175	-0.0004	-0.08	693.3170	203 25 0.12	90 54 6.89	MA 100 475
288	11	4	693.3181	-0.0010	-0.50	693.3170	203 25 0.12	90 54 6.89	MA 100 497
289	11	4	693.3178	-0.0007	-0.36	693.3170	203 25 0.12	90 54 6.89	MA 100 475
290	4	11	693.3143	0.0028	1.35	693.3170	23 24 51.23	89 6 16.09	MA 100 497
291	4	11	693.3165	0.0006	0.27	693.3170	23 24 51.23	89 6 16.09	MA 100 475
292	11	4	693.3154	0.0016	0.79	693.3170	203 25 0.12	90 54 6.89	MA 100 497
293	11	4	693.3203	-0.0033	-1.60	693.3170	203 25 0.12	90 54 6.89	MA 100 475
294	11	4	693.3177	-0.0007	-0.33	693.3170	203 25 0.12	90 54 6.89	MA 100 497
295	4	24	86.0987	-0.0005	-0.36	86.0982	93 10 48.33	89 37 25.70	MA 100 475
296	4	24	86.0976	0.0006	0.36	86.0982	93 10 48.33	89 37 25.70	MA 100 497
297	4	25	65.7996	-0.0003	-0.17	65.7993	269 14 4.26	82 5 14.16	MA 100 475
298	4	25	65.7991	0.0002	0.17	65.7993	269 14 4.26	82 5 14.16	MA 100 497
299	4	27	61.9294	0.0000	0.00	61.9294	52 32 53.88	78 3 10.63	HP 3800 0111
300	7	10	1134.4388	0.0082	0.88	1134.4471	20 15 36.75	89 33 41.63	HP 3800 1027
301	7	10	1134.4441	0.0029	0.31	1134.4471	20 15 36.75	89 33 41.63	HP 3800 1027
302	7	10	1134.4465	0.0006	0.11	1134.4471	20 15 36.75	89 33 41.63	RANGER IV 4021
303	10	7	1134.4393	0.0077	0.82	1134.4471	200 15 49.05	90 26 55.70	HP 3800 1027
304	10	7	1134.4525	-0.0054	-0.99	1134.4471	200 15 49.05	90 26 55.70	RANGER IV 4021
305	7	10	1134.4494	-0.0023	-0.42	1134.4471	20 15 36.75	89 33 41.63	RANGER IV 4021
306	7	10	1134.4437	0.0033	0.61	1134.4471	20 15 36.75	89 33 41.63	MA 100 475
307	7	10	1134.4501	-0.0031	-0.56	1134.4471	20 15 36.75	89 33 41.63	MA 100 475
308	7	10	1134.4403	0.0067	1.23	1134.4471	20 15 36.75	89 33 41.63	MA 100 497
309	7	10	1134.4489	-0.0019	-0.34	1134.4471	20 15 36.75	89 33 41.63	MA 100 497
310	10	7	1134.4560	-0.0089	-2.37	1134.4471	200 15 49.05	90 26 55.70	MA 100 475
311	10	7	1134.4528	-0.0057	-2.10	1134.4471	200 15 49.05	90 26 55.70	MA 100 497

ADJUSTED DATA: ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	V	N.V	ADJUSTED	AZ.	V.A	
312	7	10	1134.4401	0.0070	2.56	1134.4471	20 15 36.75	89 33 41.63	MA 100 497
313	7	10	1134.4414	0.0057	2.08	1134.4471	20 15 36.75	89 33 41.63	MA 100 475
314	10	7	1134.4493	-0.0022	-0.81	1134.4471	200 15 49.05	90 26 55.70	MA 100 475
315	10	7	1134.4463	0.0008	0.29	1134.4471	200 15 49.05	90 26 55.70	MA 100 497
316	12	7	145.9501	0.0029	0.58	145.9531	64 52 2.98	90 34 20.85	RANGER IV 4021
317	12	7	145.9549	-0.0018	-0.18	145.9531	64 52 2.98	90 34 20.85	RANGER IV 4021
318	12	7	145.9454	0.0076	1.50	145.9531	64 52 2.98	90 34 20.85	HP 3800 1027
319	7	12	145.9527	0.0003	0.06	145.9531	244 52 6.91	89 25 43.87	HP 3800 1027
320	7	12	145.9620	-0.0089	-1.78	145.9531	244 52 6.91	89 25 43.87	RANGER IV 4021
321	7	12	145.9535	-0.0004	-0.08	145.9531	244 52 6.91	89 25 43.87	HP 3800 1027
322	7	12	145.9642	-0.0111	-2.22	145.9531	244 52 6.91	89 25 43.87	RANGER IV 4021
323	12	7	145.9576	-0.0045	-2.94	145.9531	64 52 2.98	90 34 20.85	MA 100 475
324	12	7	145.9492	0.0039	2.52	145.9531	64 52 2.98	90 34 20.85	MA 100 497
325	12	7	145.9510	0.0021	1.35	145.9531	64 52 2.98	90 34 20.85	MA 100 475
326	7	12	145.9514	0.0017	1.10	145.9531	244 52 6.91	89 25 43.87	MA 100 475
327	7	12	145.9495	0.0036	2.34	145.9531	244 52 6.91	89 25 43.87	MA 100 497
328	7	12	145.9503	0.0028	1.82	145.9531	244 52 6.91	89 25 43.87	MA 100 497
329	7	12	145.9517	0.0014	0.90	145.9531	244 52 6.91	89 25 43.87	MA 100 475
330	11	10	69.2175	-0.0077	-1.53	69.2098	110 26 14.70	104 22 57.05	RANGER IV 4021
331	10	11	69.2070	0.0028	0.40	69.2098	290 26 16.56	75 37 5.11	HP 3800 1027
332	10	11	69.2114	-0.0016	-0.32	69.2098	290 26 16.56	75 37 5.11	RANGER IV 4021
333	11	10	69.2056	0.0042	0.60	69.2098	110 26 14.70	104 22 57.05	HP 3800 1027
334	11	10	69.2223	-0.0125	-2.51	69.2098	110 26 14.70	104 22 57.05	RANGER IV 4021
335	11	10	69.2062	0.0036	0.52	69.2098	110 26 14.70	104 22 57.05	HP 3800 1027
336	11	10	69.2078	0.0020	1.35	69.2098	110 26 14.70	104 22 57.05	MA 100 475
337	11	10	69.2072	0.0026	1.75	69.2098	110 26 14.70	104 22 57.05	MA 100 497
338	10	11	69.2121	-0.0023	-1.54	69.2098	290 26 16.56	75 37 5.11	MA 100 475
339	10	11	69.2080	0.0018	1.18	69.2098	290 26 16.56	75 37 5.11	MA 100 497
340	11	10	69.2087	0.0011	0.73	69.2098	110 26 14.70	104 22 57.05	MA 100 497
341	11	10	69.2128	-0.0030	-1.99	69.2098	110 26 14.70	104 22 57.05	MA 100 475
342	11	10	69.2093	0.0005	0.34	69.2098	110 26 14.70	104 22 57.05	MA 100 497
343	11	10	69.2095	0.0003	0.20	69.2098	110 26 14.70	104 22 57.05	MA 100 497
344	11	10	69.2112	-0.0014	-0.92	69.2098	110 26 14.70	104 22 57.05	MA 100 475
345	29	10	76.2198	0.0003	0.19	76.2201	59 12 37.90	89 57 59.71	MA 100 475
346	29	10	76.2189	0.0012	0.78	76.2201	59 12 37.90	89 57 59.71	MA 100 497
347	10	30	47.9394	0.0003	0.22	47.9397	205 9 19.89	90 6 53.67	MA 100 475
348	10	30	47.9384	0.0013	0.89	47.9397	205 9 19.89	90 6 53.67	MA 100 497
349	30	10	47.9394	0.0003	0.17	47.9397	25 9 19.29	89 53 7.89	MA 100 475
350	30	10	47.9393	0.0004	0.23	47.9397	25 9 19.29	89 53 7.89	MA 100 497
351	10	31	47.7062	-0.0010	-0.64	47.7053	175 10 14.27	90 43 36.62	MA 100 475
352	10	31	47.7075	-0.0023	-1.50	47.7053	175 10 14.27	90 43 36.62	MA 100 497
353	10	32	73.8432	0.0014	0.28	73.8446	269 38 27.12	89 25 28.34	MA 100 497
354	10	32	73.8425	0.0021	0.42	73.8446	269 38 27.12	89 25 28.34	MA 100 475
355	29	30	45.3123	-0.0007	-0.49	45.3115	95 32 36.48	90 3 53.15	MA 100 475
356	29	30	45.3103	0.0013	0.84	45.3115	95 32 36.48	90 3 53.15	MA 100 497
357	30	29	45.3106	0.0009	0.61	45.3115	275 32 37.82	89 56 8.31	MA 100 497
358	30	29	45.3137	-0.0022	-1.46	45.3115	275 32 37.82	89 56 8.31	MA 100 475
359	29	31	70.0154	0.0002	0.16	70.0157	96 59 11.43	90 27 31.12	MA 100 497
360	29	31	70.0158	-0.0002	-0.11	70.0157	96 59 11.43	90 27 31.12	MA 100 475
361	30	31	24.7480	-0.0002	-0.10	24.7478	99 37 48.74	91 10 43.20	MA 100 497

ADJUSTED DATA: ABSOLUTE DISTANCES

	FROM	TO	OBSERVED	V	N.V	ADJUSTED	AZ.	V.A	
362	30	31	24.7475	0.0003	0.23	24.7478	99 37 48.74	91 10 43.20	MA 100 475
363	13	1	35100.6567	-0.0234	-0.60	35100.6333	66 48 16.07	90 59 16.49	GEODIMETER 4 225L10A
364	13	4	35464.6941	-0.0020	-0.05	35464.6921	66 7 40.35	90 55 48.41	GEODIMETER 4 225L10A
365	13	7	35236.2932	-0.0160	-0.41	35236.2772	66 45 54.59	90 57 31.10	GEODIMETER 4 225L10A
366	13	10	36022.5294	0.0735	1.84	36022.6029	65 27 0.72	90 55 50.60	GEODIMETER 4 225L10A
367	13	19	37817.8305	-0.0307	-0.74	37817.7998	74 55 32.87	90 52 15.94	TRANS. FROM TCT
368	19	7	5800.6424	0.0013	0.10	5800.6437	314 47 9.40	90 18 52.25	RANGER IV 4021
369	19	7	5800.6460	-0.0023	-0.06	5800.6437	314 47 9.40	90 18 52.25	
370	19	10	6355.3250	-0.0228	-0.52	6355.3022	324 8 3.89	90 12 45.64	
371	33	32	41.3440	0.0006	0.39	41.3446	310 52 29.83	89 5 47.95	MA 100 497
372	33	30	27.2975	-0.0011	-0.23	27.2963	125 34 1.83	90 23 26.61	MA 100 497
373	33	30	27.2983	-0.0019	-0.39	27.2963	125 34 1.83	90 23 26.61	MA 100 475
374	33	29	25.6227	-0.0005	-0.33	25.6222	243 19 56.52	90 18 7.44	MA 100 475
375	33	29	25.6228	-0.0006	-0.39	25.6222	243 19 56.52	90 18 7.44	MA 100 497
376	29	32	39.4558	0.0010	0.65	39.4567	347 45 42.61	88 51 26.27	MA 100 497
377	29	32	39.4574	-0.0006	-0.42	39.4567	347 45 42.61	88 51 26.27	MA 100 475
378	33	31	50.7189	0.0001	0.04	50.7190	113 14 45.32	90 47 7.77	MA 100 475
379	33	31	50.7199	-0.0009	-0.62	50.7190	113 14 45.32	90 47 7.77	MA 100 497
380	33	10	50.6987	-0.0007	-0.46	50.6981	57 7 44.57	90 6 7.48	MA 100 497
381	33	10	50.6977	0.0003	0.21	50.6981	57 7 44.57	90 6 7.48	MA 100 475
382	4	26	57.7172	-0.0005	-0.33	57.7167	103 5 49.65	65 40 42.62	MA 100 475
383	4	26	57.7162	0.0005	0.33	57.7167	103 5 49.65	65 40 42.62	MA 100 497

ADJUSTED ELEVATION DIFFERENCES

	FROM	TO	MEASURED	V	N.V	ADJUSTED	
384	1	7	16.4100	-0.0009	-0.88	16.4091	1979 VERT. ADJ.
385	7	4	15.1000	-0.0003	-0.33	15.0997	1979 VERT. ADJ.
386	1	12	17.8650	0.0007	0.34	17.8657	1977 OBS. BY CJF
387	1	12	17.8660	-0.0003	-0.16	17.8657	1978 OBS. BY JEP
388	1	39	19.7820	-0.0002	-0.08	19.7818	1978 OBS. BY JEP
389	7	12	1.4580	-0.0014	-0.72	1.4566	1977 OBS. BY CJF
390	4	29	-6.3610	-0.0002	-0.15	-6.3612	1979 VERT. ADJ.
391	10	11	17.1910	-0.0000	-0.04	17.1910	1979 VERT. ADJ.
392	10	30	-0.0960	0.0000	0.04	-0.0960	1979 VERT. ADJ.
393	29	10	0.0450	-0.0001	-0.09	0.0449	1979 VERT. ADJ.
394	30	31	-0.5090	-0.0000	-0.02	-0.5090	1979 VERT. ADJ.
395	29	30	-0.0510	-0.0001	-0.06	-0.0511	1979 VERT. ADJ.
396	29	32	0.7870	-0.0000	-0.01	0.7870	1979 VERT. ADJ.
397	29	33	0.1350	0.0000	0.03	0.1350	1979 VERT. ADJ.

ADJUSTED POSITION DIFFERENCES (METERS)

	FROM	TO	LAT.	V	LON.	V	H	V	
398	11	38	0.0000	0.0000	0.0000	0.0000	7.3000	0.0000	MEAN 1977-1978 OBS.
399	12	39	0.0000	0.0000	0.0000	0.0000	1.9162	0.0002	1977 OBS. BY CJF

ADJUSTED ASTRONOMIC LATITUDES AND LONGITUDES

STATION				OBSERVED	V	N.V	ADJUSTED	SIGMA	
414	1	WESTFORD	LAT	42 36 43.66	0.09	0.30	42 36 43.75	0.37	
415	1	WESTFORD	LON	71 29 39.77	-0.20	-0.50	71 29 39.57	0.46	
416	4	MILL	LAT	42 37 1.04	-0.09	-0.31	42 37 0.95	0.36	
417	4	MILL	LON	71 29 31.94	0.28	0.70	71 29 32.22	0.44	
418	7	MICRO	LAT	42 36 48.26	-2.07	-0.21	42 36 46.19	0.38	NOT OBS.
419	7	MICRO	LON	71 29 33.62	0.86	0.06	71 29 34.48	0.47	NOT OBS.
420	10	HAYSTACK OCP NO 2	LAT	42 37 21.00	0.04	0.14	42 37 21.04	0.37	
421	10	HAYSTACK OCP NO 2	LON	71 29 16.49	-0.17	-0.43	71 29 16.32	0.45	
422	11	HAYSTACK TRUNNION	LAT	42 37 23.51	-1.71	-0.17	42 37 21.80	0.39	NOT OBS.
423	11	HAYSTACK TRUNNION	LON	71 29 19.14	-0.07	-0.00	71 29 19.07	0.46	NOT OBS.
424	12	WESTFORD ANTENNA	LAT	42 36 46.25	-2.07	-0.21	42 36 44.18	0.40	NOT OBS.
425	12	WESTFORD ANTENNA	LON	71 29 39.42	0.86	0.06	71 29 40.28	0.48	NOT OBS.
426	13	WACHUSETT 2 1937	LAT	42 29 17.60	-0.01	-0.03	42 29 17.59	0.37	
427	13	WACHUSETT 2 1937	LON	71 53 8.70	0.05	0.12	71 53 8.75	0.49	
428	19	TADMUCK MAGS 1936	LAT	42 34 33.90	0.03	0.10	42 34 33.93	0.37	
429	19	TADMUCK MAGS 1936	LON	71 26 34.57	0.02	0.04	71 26 34.59	0.50	
430	24	MILLSTONE APCS	LAT	42 37 2.74	-1.94	-0.19	42 37 0.79	0.38	NOT OBS.
431	24	MILLSTONE APCS	LON	71 29 27.46	0.99	0.07	71 29 28.45	0.46	NOT OBS.
432	25	FIREPOND DMA	LAT	42 37 2.86	-1.94	-0.19	42 37 0.92	0.38	NOT OBS.
433	25	FIREPOND DMA	LON	71 29 34.09	0.99	0.07	71 29 35.08	0.46	NOT OBS.
434	26	MILLSTONE N UPPER WALKWAY	LAT	42 37 2.50	-1.94	-0.19	42 37 0.56	0.38	NOT OBS.
435	26	MILLSTONE N UPPER WALKWAY	LON	71 29 28.98	0.99	0.07	71 29 29.97	0.46	NOT OBS.
436	27	30078 DMA	LAT	42 37 4.08	-1.94	-0.19	42 37 2.14	0.38	NOT OBS.
437	27	30078 DMA	LON	71 29 29.12	0.99	0.07	71 29 30.11	0.46	NOT OBS.
438	29	HAYSTACK OCP NO 3 1975	LAT	42 37 21.48	-1.70	-0.17	42 37 19.78	0.39	NOT OBS.
439	29	HAYSTACK OCP NO 3 1975	LON	71 29 19.26	-0.07	-0.00	71 29 19.19	0.46	NOT OBS.
440	30	HAYSTACK INTER COMP	LAT	42 37 21.34	-1.71	-0.17	42 37 19.63	0.39	NOT OBS.
441	30	HAYSTACK INTER COMP	LON	71 29 17.28	-0.07	-0.00	71 29 17.21	0.46	NOT OBS.
442	31	HAYSTACK INTER COMP RM 1	LAT	42 37 21.21	-1.71	-0.17	42 37 19.50	0.39	NOT OBS.
443	31	HAYSTACK INTER COMP RM 1	LON	71 29 16.21	-0.07	-0.00	71 29 16.14	0.46	NOT OBS.
444	32	HAYSTACK OCP NO 3 RM 1	LAT	42 37 22.73	-1.71	-0.17	42 37 21.03	0.39	NOT OBS.
445	32	HAYSTACK OCP NO 3 RM 1	LON	71 29 19.62	-0.07	-0.00	71 29 19.56	0.46	NOT OBS.
446	33	HAYSTACK OCP NO 3 RM 2	LAT	42 37 21.86	-1.71	-0.17	42 37 20.15	0.39	NOT OBS.
447	33	HAYSTACK OCP NO 3 RM 2	LON	71 29 18.25	-0.07	-0.00	71 29 18.19	0.46	NOT OBS.

ADJUSTED ASTRONOMIC LATITUDES AND LONGITUDES

STATION				OBSERVED	V	N.V	ADJUSTED	SIGMA	
448	38	HAYSTACK VLBI	LAT	42 37 23.51	-1.71	-0.17	42 37 21.80	0.39	NOT OBS.
449	38	HAYSTACK VLBI	LON	71 29 19.14	-0.07	-0.00	71 29 19.07	0.46	NOT OBS.
450	39	WESTFORD VLBI	LAT	42 36 46.25	-2.07	-0.21	42 36 44.18	0.40	NOT OBS.
451	39	WESTFORD VLBI	LON	71 29 39.42	0.86	0.06	71 29 40.28	0.48	NOT OBS.

GEODETIC LATITUDE CONSTRAINTS

STATION		CONSTRAINED	V	N.V	ADJUSTED	SIGMA
452	19	42 34 35.87200	0.00000	0.00004	42 34 35.87200	0.00004

GEODETIC LONGITUDE CONSTRAINTS

STATION		CONSTRAINED	V	N.V	ADJUSTED	SIGMA
453	19	71 26 33.00000	-0.00000	-0.00002	71 26 33.00000	0.00005

GEODETIC HEIGHT CONSTRAINTS

STATION		CONSTRAINED	V	N.V	ADJUSTED	SIGMA
454	1	95.6420	0.0000	0.0	95.6420	0.001

ADJUSTED CARTESIAN COORDINATES

DX	DY	DZ	EPSILON	PSI	OMEGA	SCALE
-29.236	155.625	187.220	0.0	0.0	0.0	0.0

STATION		X	Y	Z	TRANSFORMED COORDINATES X	Y	Z
1	WESTFORD	1492233.138	-4458284.535	4295802.441	1492203.902	-4458128.910	4295989.661
4	MILL	1492288.732	-4457914.350	4296211.359	1492259.496	-4457758.725	4296398.579
7	MICRO	1492330.517	-4458211.001	4295868.879	1492301.281	-4458055.376	4296056.099
10	HAYSTACK OCP NO 2	1492476.349	-4457409.103	4296657.969	1492447.113	-4457253.478	4296845.189
11	HAYSTACK TRUNNION	1492415.761	-4457426.012	4296686.836	1492386.525	-4457270.387	4296874.056
12	WESTFORD ANTENNA	1492218.881	-4458293.752	4295824.248	1492189.645	-4458138.127	4296011.463
13	WACHUSETT 2 1937	1464615.028	-4477612.150	4286017.873	1464585.792	-4477456.525	4286205.093
19	TADMUCK MAGS 1936	1497120.680	-4459543.923	4292881.383	1497091.444	-4459388.298	4293068.603
24	MILLSTONE APCS	1492371.408	-4457890.523	4296208.227	1492342.172	-4457734.898	4296395.447
25	FIREPOND DMA	1492229.238	-4457941.916	4296216.852	1492200.002	-4457786.291	4296404.072
26	MILLSTONE N UPPER WALKWAY	1492345.423	-4457922.329	4296218.684	1492316.187	-4457766.704	4296405.904
27	30078 DMA	1492329.419	-4457884.372	4296247.152	1492300.183	-4457728.747	4296434.372
29	HAYSTACK OCP NO 3 1975	1492422.637	-4457454.914	4296629.230	1492393.401	-4457299.289	4296816.450
30	HAYSTACK INTER COMP	1492466.332	-4457443.370	4296625.974	1492437.096	-4457287.745	4296813.194
31	HAYSTACK INTER COMP RM 1	1492490.235	-4457437.928	4296622.584	1492460.999	-4457282.303	4296809.804
32	HAYSTACK OCP NO 3 RM 1	1492406.603	-4457433.363	4296658.131	1492377.367	-4457277.738	4296845.351
33	HAYSTACK OCP NO 3 RM 2	1492441.908	-4457440.355	4296637.783	1492412.672	-4457284.730	4296825.003
38	HAYSTACK VLBI	1492417.467	-4457431.106	4296691.780	1492383.231	-4457275.481	4296879.000
39	WESTFORD VLBI	1492219.328	-4458295.089	4295825.545	1492190.092	-4458139.464	4296012.765

MISCELLANEOUS DATA FOR SELECTED LINES, PART 1

FROM	TO		STANDARD ERRORS	CORRELATION COEFF. AZ.	DIST.	V.A.		STANDARD ERRORS	CORRELATION COEFF. DX	DY	DZ	DX,DY,DZ	AZ.,DIST.,V.A.	AZ.,DIST.,B.AZ. (GEODETIC)
1	4	AZ.	0.50	1.00	-0.02	-0.01	DX	0.001	1.00	-0.19	0.06	55.594	17 54 38.08	17 54 38.68
		DIST.	0.001	-0.02	1.00	-0.01	DY	0.001	-0.19	1.00	-0.74	370.186	554.384	553.478
		V.A.	0.61	-0.01	-0.01	1.00	DZ	0.001	0.06	-0.74	1.00	408.918	86 44 39.50	197 54 43.74
1	7	AZ.	1.03	1.00	0.09	-0.03	DX	0.001	1.00	-0.11	0.00	97.379	56 58 52.16	56 58 52.93
		DIST.	0.001	0.09	1.00	-0.08	DY	0.001	-0.11	1.00	-0.48	73.534	138.939	137.964
		V.A.	1.54	-0.03	-0.08	1.00	DZ	0.001	0.00	-0.48	1.00	66.437	83 13 4.69	236 58 56.36
1	10	AZ.	0.42	1.00	0.01	0.15	DX	0.002	1.00	-0.27	-0.01	243.211	24 3 0.61	24 3 1.21
		DIST.	0.001	0.01	1.00	0.01	DY	0.002	-0.27	1.00	-0.75	875.432	1247.983	1247.707
		V.A.	0.48	0.15	0.01	1.00	DZ	0.002	-0.01	-0.75	1.00	855.528	88 50 56.39	204 3 16.32
1	11	AZ.	0.43	1.00	-0.01	0.12	DX	0.002	1.00	-0.24	0.03	182.624	20 58 13.13	20 58 13.74
		DIST.	0.001	-0.01	1.00	0.05	DY	0.002	-0.24	1.00	-0.76	858.523	1246.021	1245.276
		V.A.	0.52	0.12	0.05	1.00	DZ	0.002	0.03	-0.76	1.00	884.395	88 3 22.92	200 58 26.98
1	12	AZ.	7.30	1.00	-0.09	-0.12	DX	0.001	1.00	0.10	0.01	-14.257	308 44 33.01	308 44 31.89
		DIST.	0.001	-0.09	1.00	0.56	DY	0.001	0.10	1.00	-0.47	-9.216	27.636	21.084
		V.A.	6.42	-0.12	0.56	1.00	DZ	0.001	0.01	-0.47	1.00	21.807	49 43 27.56	128 44 31.40
1	29	AZ.	0.44	1.00	0.03	0.13	DX	0.002	1.00	-0.17	-0.02	189.499	21 55 47.40	21 55 48.00
		DIST.	0.001	0.03	1.00	-0.00	DY	0.002	-0.17	1.00	-0.60	829.621	1186.491	1186.204
		V.A.	0.47	0.13	-0.00	1.00	DZ	0.002	-0.02	-0.60	1.00	826.789	88 47 27.32	201 56 1.17
1	30	AZ.	0.44	1.00	0.01	0.14	DX	0.002	1.00	-0.24	-0.01	233.194	24 0 22.25	24 0 22.85
		DIST.	0.001	0.01	1.00	0.01	DY	0.002	-0.24	1.00	-0.64	841.165	1200.060	1199.777
		V.A.	0.49	0.14	0.01	1.00	DZ	0.002	-0.01	-0.64	1.00	823.533	88 48 25.78	204 0 37.35
1	38	AZ.	0.44	1.00	-0.01	0.09	DX	0.002	1.00	-0.31	0.16	184.329	20 58 13.13	20 58 13.74
		DIST.	0.001	-0.01	1.00	0.09	DY	0.003	-0.31	1.00	-0.81	853.430	1246.291	1245.276
		V.A.	0.66	0.09	0.09	1.00	DZ	0.003	0.16	-0.81	1.00	889.338	87 43 15.45	200 58 26.98
7	12	AZ.	1.17	1.00	0.01	0.09	DX	0.001	1.00	-0.18	-0.07	-111.636	244 52 6.91	244 52 7.48
		DIST.	0.001	0.01	1.00	0.36	DY	0.001	-0.18	1.00	-0.57	-82.751	145.953	145.943
		V.A.	1.99	0.09	0.36	1.00	DZ	0.001	-0.07	-0.57	1.00	-44.631	89 25 43.87	64 52 3.55
10	11	AZ.	2.24	1.00	-0.00	0.01	DX	0.001	1.00	-0.21	0.27	-60.587	290 26 16.56	290 26 16.11
		DIST.	0.001	-0.00	1.00	0.32	DY	0.001	-0.21	1.00	-0.40	-16.909	69.210	67.039
		V.A.	3.29	0.01	0.32	1.00	DZ	0.001	0.27	-0.40	1.00	28.867	75 37 5.11	110 26 14.24
10	12	AZ.	0.39	1.00	-0.03	-0.08	DX	0.002	1.00	-0.27	-0.03	-257.468	204 59 42.13	204 59 42.09
		DIST.	0.001	-0.03	1.00	0.05	DY	0.002	-0.27	1.00	-0.71	-884.648	1242.571	1242.527
		V.A.	0.50	-0.08	0.05	1.00	DZ	0.002	-0.03	-0.71	1.00	-833.721	90 20 36.75	24 59 26.49
10	30	AZ.	2.91	1.00	0.02	0.00	DX	0.001	1.00	-0.14	0.16	-10.016	205 9 19.89	205 9 19.85
		DIST.	0.001	0.02	1.00	-0.01	DY	0.001	-0.14	1.00	-0.37	-34.267	47.940	47.939
		V.A.	4.36	0.00	-0.01	1.00	DZ	0.001	0.16	-0.37	1.00	-31.995	90 6 53.67	25 9 19.25

MISCELLANEOUS DATA FOR SELECTED LINES, PART 1

FROM	TO		STANDARD ERRORS	CORRELATION COEFF. AZ.	DIST.	V.A.		STANDARD ERRORS	CORRELATION COEFF. DX	DY	DZ	DX,DY,DZ	AZ.,DIST.,V.A.	AZ.,DIST.,B.AZ. (GEODETIC)
11	12	AZ.	0.41	1.00	-0.05	-0.08	DX	0.002	1.00	-0.24	0.02	-196.881	201 54 9.67	201 54 9.64
		DIST.	0.001	-0.05	1.00	0.01	DY	0.002	-0.24	1.00	-0.72	-867.740	1239.271	1239.004
		V.A.	0.55	-0.08	0.01	1.00	DZ	0.002	0.02	-0.72	1.00	-862.588	91 8 21.46	21 53 55.91
29	30	AZ.	3.08	1.00	-0.04	-0.00	DX	0.001	1.00	-0.11	0.16	43.695	95 32 36.48	95 32 36.43
		DIST.	0.001	-0.04	1.00	-0.01	DY	0.001	-0.11	1.00	-0.37	11.544	45.312	45.311
		V.A.	4.61	-0.00	-0.01	1.00	DZ	0.001	0.16	-0.37	1.00	-3.256	90 3 53.15	275 32 37.77
30	38	AZ.	3.01	1.00	0.05	-0.01	DX	0.001	1.00	-0.41	0.43	-48.865	327 34 13.68	327 34 13.36
		DIST.	0.001	0.05	1.00	0.54	DY	0.002	-0.41	1.00	-0.71	12.265	82.877	79.144
		V.A.	6.98	-0.01	0.54	1.00	DZ	0.002	0.43	-0.71	1.00	65.805	72 44 33.85	147 34 12.10
30	39	AZ.	0.43	1.00	-0.02	-0.08	DX	0.002	1.00	-0.27	0.05	-247.004	204 59 18.34	204 59 18.30
		DIST.	0.001	-0.02	1.00	0.03	DY	0.002	-0.27	1.00	-0.64	-851.719	1194.622	1194.588
		V.A.	0.60	-0.08	0.03	1.00	DZ	0.002	0.05	-0.64	1.00	-800.429	90 15 37.38	24 59 3.31
38	10	AZ.	2.95	1.00	0.00	-0.00	DX	0.001	1.00	-0.50	0.52	58.882	110 26 14.87	110 26 14.24
		DIST.	0.001	0.00	1.00	-0.68	DY	0.002	-0.50	1.00	-0.77	22.002	71.374	67.039
		V.A.	7.48	-0.00	-0.68	1.00	DZ	0.002	0.52	-0.77	1.00	-33.810	110 4 5.75	290 26 16.11
38	12	AZ.	0.42	1.00	-0.05	-0.06	DX	0.002	1.00	-0.31	0.15	-198.586	201 54 9.66	201 54 9.64
		DIST.	0.001	-0.05	1.00	-0.03	DY	0.003	-0.31	1.00	-0.78	-862.646	1239.438	1239.004
		V.A.	0.69	-0.06	-0.03	1.00	DZ	0.003	0.15	-0.78	1.00	-867.532	91 28 36.08	21 53 55.91
38	29	AZ.	3.69	1.00	0.05	0.01	DX	0.001	1.00	-0.40	0.44	5.170	182 26 12.06	182 26 12.07
		DIST.	0.002	0.05	1.00	-0.58	DY	0.002	-0.40	1.00	-0.71	-23.808	67.127	62.481
		V.A.	8.43	0.01	-0.58	1.00	DZ	0.002	0.44	-0.71	1.00	-62.550	111 26 22.33	2 26 11.99
38	30	AZ.	3.01	1.00	0.05	0.01	DX	0.001	1.00	-0.41	0.43	48.865	147 34 12.42	147 34 12.10
		DIST.	0.001	0.05	1.00	-0.54	DY	0.002	-0.41	1.00	-0.71	-12.265	82.877	79.144
		V.A.	6.98	0.01	-0.54	1.00	DZ	0.002	0.43	-0.71	1.00	-65.805	107 15 28.71	327 34 13.36
38	39	AZ.	0.43	1.00	-0.04	-0.07	DX	0.003	1.00	-0.32	0.18	-198.139	201 54 9.66	201 54 9.64
		DIST.	0.001	-0.04	1.00	-0.03	DY	0.003	-0.32	1.00	-0.77	-863.983	1239.390	1239.004
		V.A.	0.73	-0.07	-0.03	1.00	DZ	0.003	0.18	-0.77	1.00	-866.234	91 23 17.29	21 53 55.91
39	10	AZ.	0.45	1.00	-0.03	0.12	DX	0.002	1.00	-0.29	0.05	257.020	24 59 25.90	24 59 26.49
		DIST.	0.001	-0.03	1.00	-0.02	DY	0.002	-0.29	1.00	-0.70	885.985	1242.562	1242.527
		V.A.	0.58	0.12	-0.02	1.00	DZ	0.002	0.05	-0.70	1.00	832.424	89 45 22.19	204 59 42.09
39	11	AZ.	0.46	1.00	-0.03	0.09	DX	0.002	1.00	-0.27	0.08	196.433	21 53 55.32	21 53 55.91
		DIST.	0.001	-0.03	1.00	0.01	DY	0.002	-0.27	1.00	-0.71	869.077	1239.235	1239.004
		V.A.	0.62	0.09	0.01	1.00	DZ	0.002	0.08	-0.71	1.00	861.291	88 57 38.13	201 54 9.64
39	29	AZ.	0.47	1.00	-0.00	0.10	DX	0.002	1.00	-0.22	0.04	203.309	22 54 34.26	22 54 [illegible].35
		DIST.	0.001	-0.00	1.00	-0.02	DY	0.002	-0.22	1.00	-0.61	840.175	1180.312	1[illegible].278
		V.A.	0.58	0.10	-0.02	1.00	DZ	0.002	0.04	-0.61	1.00	803.685	89 44 41.62	202 54 [illegible].50

MISCELLANEOUS DATA FOR SELECTED LINES, PART 1

FROM	TO	STANDARD ERRORS		CORRELATION COEFF. AZ.	DIST.	V.A.	STANDARD ERRORS		CORRELATION COEFF. DX	DY	DZ	DX,DY,DZ	AZ.,DIST.,V.A.	AZ.,DIST.,B.AZ. (GEODETIC)
39	30	AZ.	0.47	1.00	-0.02	0.11	DX	0.002	1.00	-0.27	0.05	247.004	24 59 2.72	24 59 3.31
		DIST.	0.001	-0.02	1.00	-0.02	DY	0.002	-0.27	1.00	-0.64	851.719	1194.622	1194.588
		V.A.	0.60	0.11	-0.02	1.00	DZ	0.002	0.05	-0.64	1.00	800.429	89 45 1.92	204 59 18.30
39	38	AZ.	0.47	1.00	-0.03	0.08	DX	0.003	1.00	-0.32	0.18	198.139	21 53 55.31	21 53 55.91
		DIST.	0.001	-0.03	1.00	0.04	DY	0.003	-0.32	1.00	-0.77	863.983	1239.390	1239.004
		V.A.	0.74	0.08	0.04	1.00	DZ	0.003	0.18	-0.77	1.00	866.234	88 37 23.43	201 54 9.64

MISCELLANEOUS DATA FOR SELECTED LINES, PART 2

FROM	TO	EQUATORIAL SYSTEM ALTITUDE	AZIMUTH	DISTANCE	HORIZON SYSTEM, ORIGIN AT THE STANDPOINT DN	SIGMA	DE	SIGMA	DU	SIGMA
1	4	47 31 40.75	81 27 33.11	554.384	526.666	0.001	170.216	0.001	31.485	0.002
1	7	28 33 59.36	37 3 27.63	138.939	75.180	0.001	115.684	0.001	16.408	0.001
1	10	43 16 37.97	74 28 25.47	1247.983	1139.414	0.001	508.496	0.002	25.069	0.003
1	11	45 12 59.91	77 59 28.08	1246.021	1162.822	0.001	445.675	0.002	42.260	0.003
1	12	52 5 55.59	212 52 49.75	27.636	13.195	0.001	-16.445	0.001	17.866	0.001
1	29	44 10 25.12	77 8 0.37	1186.491	1100.394	0.001	443.021	0.002	25.036	0.002
1	30	43 20 0.41	74 30 18.51	1200.060	1096.019	0.001	488.121	0.002	24.982	0.003
1	38	45 31 39.31	77 48 43.63	1246.291	1162.824	0.001	445.675	0.002	49.560	0.004
7	12	17 48 20.21	216 32 52.08	145.953	-61.983	0.001	-132.130	0.001	1.455	0.001
10	11	24 39 3.95	195 35 35.55	69.210	23.410	0.001	-62.821	0.001	17.191	0.001
10	12	42 8 29.61	253 46 22.42	1242.571	-1126.177	0.001	-525.026	0.002	-7.450	0.003
10	30	41 52 0.05	253 42 21.53	47.940	-43.393	0.001	-20.378	0.001	-0.096	0.001
11	12	44 6 37.93	257 12 59.86	1239.271	-1149.592	0.001	-462.195	0.002	-24.641	0.003
29	30	4 7 12.43	14 47 55.84	45.312	-4.377	0.001	45.100	0.001	-0.051	0.001
30	38	52 33 43.23	165 54 37.62	82.877	66.803	0.001	-42.443	0.001	24.586	0.003
30	39	42 4 8.92	253 49 38.99	1194.622	-1082.786	0.002	-504.645	0.002	-5.429	0.003
38	10	28 16 29.75	20 29 20.37	71.374	-23.410	0.001	62.821	0.001	-24.491	0.003
38	12	44 25 19.78	257 2 9.71	1239.438	-1149.592	0.001	-462.195	0.002	-31.941	0.004
38	29	68 43 7.81	282 15 6.19	67.127	-62.426	0.001	-2.656	0.001	-24.536	0.003
38	30	52 33 43.23	345 54 37.62	82.877	-66.803	0.001	42.443	0.001	-24.587	0.003
38	39	44 20 25.44	257 5 1.02	1239.390	-1149.592	0.002	-462.196	0.002	-30.024	0.004
39	10	42 3 40.80	73 49 22.06	1242.562	1126.220	0.001	524.938	0.002	5.288	0.003
39	11	44 1 43.24	77 15 49.41	1239.235	1149.628	0.001	462.117	0.002	22.480	0.003
39	29	42 54 52.82	76 23 48.63	1180.312	1087.199	0.002	459.464	0.002	5.255	0.003
39	30	42 4 8.92	73 49 38.99	1194.622	1082.825	0.002	504.564	0.002	5.201	0.003
39	38	44 20 25.44	77 5 1.02	1239.390	1149.630	0.002	462.118	0.002	29.780	0.004

APPENDIX C.--LISTING OF ORTHOMETRIC HEIGHTS

The following computerized listing is the output of the leveling adjustment program.

LEVELING ADJUSTMENT OF 28 JUN 1979 PAGE 1
LOWELL TO HAYSTACK OBSERVATORY MA HGZ L24426 PART 1
DCF/NGS 17 SEP 1977 22 SEP 1978 3.0 MM 1ST-ORDER/CLASS I

BENCH MARKS	ADJUSTED ORTHOMETRIC HEIGHT (METERS)	(FEET)	APPROX LATITUDE DD MM SS		POSITION LONGITUDE DDD MM SS	
Z 33	46.410	152.263	42 37 10	N	71 16 19	W
43 AZ MAGS	36.589	120.043	42 37 32	N	71 17 44	W
X 33	33.975	111.466	42 37 40	N	71 17 57	W
R 1	34.505	113.207	42 37 41	N	71 18 33	W
79 AB MADPW	34.102	111.884	42 37 45	N	71 18 37	W
U 7	30.698	100.716	42 38 23	N	71 19 9	W
T 7	32.735	107.400	42 38 23	N	71 19 32	W
PWD Q 27 BMRR	32.255	105.825	42 38 26	N	71 19 49	W
G 18	38.480	126.247	42 38 18	N	71 20 35	W
H 18	33.375	109.499	42 38 4	N	71 21 35	W
S 7	31.605	103.690	42 38 13	N	71 22 35	W
R 7	31.862	104.535	42 38 16	N	71 22 36	W
J 18	39.056	128.136	42 38 18	N	71 22 59	W
K 18	39.827	130.666	42 38 20	N	71 23 27	W
L 18	52.907	173.579	42 37 51	N	71 24 26	W
M 18	57.356	188.177	42 37 27	N	71 25 29	W
N 18	73.003	239.509	42 37 8	N	71 26 39	W
P 18	63.578	208.587	42 36 42	N	71 27 29	W
Q 18	81.141	266.210	42 36 26	N	71 28 33	W
R 18	77.708	254.946	42 36 14	N	71 29 43	W
WESTFORD MON SITE RM 2	86.181	282.744	42 36 32	N	71 29 39	W
WESTFORD MON SITE USCG	85.971	282.056	42 36 32	N	71 29 39	W
WESTFORD MON SITE RM 1	85.861	281.697	42 36 32	N	71 29 39	W
WESTFORD RM 1	96.796	317.571	42 36 46	N	71 29 39	W
WESTFORD RM 2	96.639	317.058	42 36 44	N	71 29 39	W
WESTFORD	96.242	315.753	42 36 46	N	71 29 39	W
MICRO RM 2	112.941	370.541	42 36 46	N	71 29 39	W
MICRO	112.652	369.593	42 36 47	N	71 29 32	W
WESTFORD ANTENNA	114.106	374.363	42 36 46	N	71 29 39	W
MICRO RM 1	112.731	369.851	42 36 47	N	71 29 32	W

LEVELING ADJUSTMENT OF 28 JUN 1979 PAGE 2
LOWELL TO HAYSTACK OBSERVATORY MA HGZ L24426 PART 1
DCF/NGS 17 SEP 1977 22 SEP 1978 3.0 MM 1ST-ORDER/CLASS I

BENCH MARKS	ADJUSTED ORTHOMETRIC HEIGHT (METERS)	(FEET)	APPROX LATITUDE DD MM SS		POSITION LONGITUDE DDD MM SS	
MILL RM 1	126.512	415.065	42 37 2	N	71 29 30	W
MILL	127.752	419.132	42 37 2	N	71 29 30	W
HAYSTACK OCP 3 RM 1	122.178	400.845	42 37 23	N	71 29 20	W
HAYSTACK OCP 3 RM 2	121.526	398.706	42 37 23	N	71 29 20	W
HAYSTACK OCP 3	121.391	398.263	42 37 22	N	71 29 18	W
HAYSTACK INTER COMP RM 1	120.831	396.425	42 37 20	N	71 29 16	W
HAYSTACK INTER COMP	121.340	398.096	42 37 20	N	71 29 16	W
HAYSTACK OCP 2	121.436	398.410	42 37 23	N	71 29 16	W
S 18	121.874	399.847	42 37 24	N	71 29 20	W

LEVELING ADJUSTMENT OF 28 JUN 1979 — PAGE 1
LOWELL TO HAYSTACK OBSERVATORY MA — HGZ L24426 PART 2
DCF/NGS — 17 SEP 1977 — 22 SEP 1978 — 3.0 MM 1ST-ORDER/CLASS I

BENCH MARKS	ADJUSTED ORTHOMETRIC HEIGHT (METERS)	(FEET)	APPROX LATITUDE DD MM SS		POSITION LONGITUDE DDD MM SS	
WESTFORD RM 2	96.639	317.058	42 36 44	N	71 29 39	W
MICRO RM 1	112.731	369.851	42 36 47	N	71 29 32	W
WESTFORD ANTENNA	114.106	374.363	42 36 46	N	71 29 39	W
WESTFORD VLBI	116.022	380.649	42 36 46	N	71 29 39	W
WESTFORD	96.242	315.753	42 36 46	N	71 29 39	W
MICRO	112.652	369.593	42 36 47	N	71 29 32	W
MILL RM 2	127.102	417.001	42 37 2	N	71 29 30	W
MILL RM 1	126.512	415.065	42 37 2	N	71 29 30	W
MILL	127.752	419.132	42 37 2	N	71 29 30	W
HAYSTACK OCP 3	121.391	398.263	42 37 22	N	71 29 18	W
HAYSTACK OCP 2	121.436	398.410	42 37 23	N	71 29 16	W
HAYSTACK TRUNNION	138.627	454.813	42 37 23	N	71 29 18	W
HAYSTACK VLBI	145.927	478.761	42 37 23	N	71 29 18	W

APPENDIX D.--LISTING OF GRAVITY VALUES

The following computerized listing is the output of the gravity reduction and adjustment program.

ADJUSTED VALUES OF GRAVITY

STATION AG	PROJ	NUM	NAME	LATITUDE DEG MIN	LONGITUDE DEG MIN	ELEVATION(M) PRIME.	SECOND.	GRAVITY MGAL	SIGMA	FREE AIR MGAL	SIGMA MGAL	BOUGUER MGAL	SIGMA MGAL
0	0	802	DRIFT STA 2	42 36.00	71 27.00	0.0	0.02	980384.147	0.008	-17.972	0.500	-17.972	0.500
6	2633	903	BOSTON J	42 27.90	71 17.10	38.50	0.00	980381.986	0.006	3.919	0.500	-0.390	0.500
6	2633	904	BOSTON B	42 27.90	71 16.10	42.60	0.00	980380.335	0.006	3.531	0.500	-1.236	0.500
6	2633	21	Z 33	42 37.20	71 16.30	46.41	0.02	980397.382	0.012	7.782	0.500	2.589	0.500
6	2633	22	43 AZ MAGS	42 37.50	71 17.70	36.59	0.02	980400.084	0.015	7.002	0.500	2.907	0.500
6	2633	23	X 33	42 37.70	71 18.00	33.97	0.02	980401.200	0.015	7.011	0.500	3.209	0.500
6	2633	24	R 1	42 37.70	71 18.50	34.50	0.00	980400.942	0.015	6.916	0.500	3.055	0.500
6	2633	25	79 AB MADPW	42 37.80	71 18.60	34.10	0.02	980401.449	0.012	7.148	0.500	3.332	0.500
6	2633	26	U 7	42 38.40	71 19.10	30.70	0.02	980404.865	0.015	8.612	0.500	5.177	0.500
6	2633	27	T 7	42 38.40	71 19.50	32.73	-0.13	980403.551	0.015	7.927	0.500	4.264	0.500
6	2633	28	PWD Q 27 BMR	42 38.40	71 19.80	32.25	0.02	980402.771	0.015	6.999	0.500	3.390	0.500
6	2633	29	G 18	42 38.30	71 20.60	38.48	0.02	980399.231	0.015	5.530	0.500	1.224	0.500
6	2633	30	H 18	42 38.10	71 21.60	35.38	0.05	980399.176	0.015	4.200	0.500	0.466	0.500
6	2633	31	S 7	42 38.20	71 22.60	31.61	0.02	980397.074	0.012	1.402	0.500	-2.135	0.500
6	2633	32	R 7	42 38.30	71 22.60	31.86	0.02	980396.312	0.015	0.569	0.500	-2.996	0.500
6	2633	33	J 18	42 38.30	71 23.00	39.06	0.03	980394.185	0.015	0.662	0.500	-3.708	0.500
6	2633	34	K 18	42 38.30	71 23.50	39.83	0.00	980391.044	0.015	-2.241	0.500	-6.699	0.500
6	2633	35	L 18	42 37.90	71 24.40	52.91	0.02	980386.649	0.010	-1.999	0.500	-7.919	0.500
6	2633	36	M 18	42 37.40	71 25.50	57.36	0.02	980384.366	0.015	-2.157	0.500	-8.576	0.500
6	2633	37	N 18	42 37.10	71 26.70	73.00	0.04	980380.582	0.015	-0.662	0.500	-8.831	0.500
6	2633	38	P 18	42 36.70	71 27.50	65.58	0.02	980381.496	0.015	-1.438	0.500	-8.776	0.500
6	2633	39	Q 18	42 36.50	71 28.60	81.14	0.02	980378.350	0.015	0.519	0.500	-8.560	0.500
6	2633	40	R 18	42 36.20	71 29.70	77.71	0.02	980379.580	0.015	1.140	0.500	-7.555	0.500
6	2633	41	WESTFORD MS2	42 36.50	71 29.70	86.18	0.02	980377.903	0.010	1.627	0.500	-8.016	0.500
6	2633	42	WESTFORD MS	42 36.50	71 29.70	85.97	0.02	980378.067	0.015	1.727	0.500	-7.893	0.500
6	2633	43	WESTFORD MS1	42 36.50	71 29.70	85.86	0.02	980378.104	0.014	1.729	0.500	-7.879	0.500
6	2633	44	WESTFORD RM1	42 36.80	71 29.60	96.80	0.02	980376.646	0.014	3.196	0.500	-7.656	0.500
6	2633	45	WESTFORD	42 36.80	71 29.60	96.24	0.02	980376.747	0.009	3.125	0.500	-7.644	0.500
6	2633	46	WESTFORD RM2	42 36.80	71 29.60	96.64	0.02	980376.522	0.014	3.023	0.500	-7.791	0.500
6	2633	47	MICRO RM2	42 36.80	71 29.60	112.94	0.02	980373.380	0.014	4.912	0.500	-7.727	0.500
6	2633	48	MICRO	42 36.80	71 29.50	112.65	0.02	980373.484	0.014	4.926	0.500	-7.680	0.500
6	2633	49	MICRO RM 1	42 36.80	71 29.50	112.73	0.02	980373.353	0.012	4.820	0.500	-7.794	0.500
6	2633	50	MILL RM 1	42 37.00	71 29.50	126.51	0.02	980371.363	0.014	6.782	0.500	-7.375	0.500
6	2633	51	MILL	42 37.00	71 29.50	129.75	0.02	980371.086	0.014	7.505	0.500	-7.014	0.500
6	2633	52	MILL RM 2	42 37.00	71 29.50	127.10	0.02	980371.114	0.014	6.715	0.500	-7.508	0.500
6	2633	53	TBM 1 MISA	42 37.00	71 29.50	121.28	-0.11	980372.857	0.014	6.660	0.500	-6.911	0.500
6	2633	54	S 18	42 37.40	71 29.30	121.87	0.02	980373.184	0.008	6.571	0.500	-7.067	0.500
6	2633	55	OCP 3 RM 1	42 37.40	71 29.30	122.18	0.02	980373.122	0.014	6.603	0.500	-7.069	0.500
6	2633	56	OCP 3 RM 2	42 37.40	71 29.30	121.53	0.02	980373.236	0.014	6.515	0.500	-7.084	0.500
6	2633	57	OCP 3	42 37.40	71 29.30	121.39	-0.04	980373.219	0.014	6.457	0.500	-7.127	0.500
6	2633	58	OCP 2	42 37.40	71 29.30	121.44	-0.04	980373.258	0.014	6.509	0.500	-7.080	0.500
6	2633	59	INTER COMP	42 37.30	71 29.30	121.34	0.06	980373.163	0.014	6.535	0.500	-7.043	0.500
6	2633	60	INTER CO	42 37.30	71 29.30	120.83	0.02	980373.232	0.014	6.447	0.500	-7.074	0.500
6	2633	61	APCS 1	42 37.00	71 29.50	127.00	0.02	980370.759	0.014	6.328	0.500	-7.883	0.500
6	2633	62	APCS 2	42 37.00	71 29.50	127.00	0.02	980370.613	0.014	6.383	0.500	-7.928	0.500
6	2633	63	FIRE POND	42 36.90	71 29.50	127.00	0.02	980367.821	0.014	3.541	0.500	-10.670	0.500
6	2633	64	WESTFORD TOW	42 36.80	71 29.60	113.00	0.10	980371.100	0.014	2.650	0.500	-9.995	0.500
0	0	905	BOSTON A	42 26.00	71 18.00	40.00	0.00	980378.671	0.000	0.914	0.500	-3.562	0.500

(Continued from inside front cover)

NOS NGS-6 Determination of North American Datum 1983 coordinates of map corners. T. Vincenty, October 1976, 8 pp (PB262442). Predictions of changes in coordinates of map corners are detailed.

NOS NGS-7 Recent elevation change in Southern California. S.R. Holdahl, February 1977, 19 pp (PB265-940). Velocities of elevation change were determined from Southern Calif. leveling data for 1906-62 and 1959-76 epochs.

NOS NGS-8 Establishment of calibration base lines. Joseph F. Dracup, Charles J. Fronczek, and Raymond W. Tomlinson, August 1977, 22 pp (PB277130). Specifications are given for establishing calibration base lines.

NOS NGS-9 National Geodetic Survey publications on surveying and geodesy 1976. September 1977, 17 pp (PB275181). Compilation lists publications authored by NGS staff in 1976, source availability for out-of-print Coast and Geodetic Survey publications, and subscription information on the Geodetic Control Data Automatic Mailing List.

NOS NGS-10 Use of calibration base lines. Charles J. Fronczek, December 1977, 38 pp (PB279574). Detailed explanation allows the user to evaluate electromagnetic distance measuring instruments.

NOS NGS-11 Applicability of array algebra. Richard A. Snay, February 1978, 22 pp (PB281196). Conditions required for the transformation from matrix equations into computationally more efficient array equations are considered.

NOS NGS-12 The TRAV-10 horizontal network adjustment program. Charles R. Schwarz, April 1978, 52 pp (PB283087). The design, objectives, and specifications of the horizontal control adjustment program are presented.

NOS NGS-13 Application of three-dimensional geodesy to adjustments of horizontal networks. T. Vincenty and B. R. Bowring, June 1978, 7 pp (PB286672). A method is given for adjusting measurements in three-dimensional space without reducing them to any computational surface.

NOS NGS-14 Solvability analysis of geodetic networks using logical geometry. Richard A. Snay, October 1978, 29 pp (PB291286). No algorithm based solely on logical geometry has been found that can unerringly distinguish between solvable and unsolvable horizontal networks. For leveling networks such an algorithm is well known.

NOS NGS-15 Goldstone validation survey - phase 1. William E. Carter and James E. Pettey, November 1978, 44 pp (PB292310). Results are given for a space system validation study conducted at the Goldstone, Calif., Deep Space Communication Complex.

NOS NGS-16 Determination of North American Datum 1983 coordinates of map corners (Second Prediction). T. Vincenty, April 1979, 6 pp (PB297245). New predictions of changes in coordinates of of map corners are given.

NOS NGS-17 The HAVAGO three-dimensional adjustment program. T. Vincenty, May 1979, 18 pp (PB297069). The HAVAGO computer program adjusts numerous kinds of geodetic observations for high precision special surveys and ordinary surveys.

NOS NGS-18 Determination of astronomic positions for California-Nevada boundary monuments near Lake Tahoe. James E. Pettey, March, 1979. Astronomic observations of the 120th meridian were made at the request of the Calif. State Lands Commission.

NOS NGS-19 HOACOS: A program for adjusting horizontal networks in three dimensions. T. Vincenty, July 1979, 13 pp. Horizontal networks are adjusted simply and efficiently in the height-controlled spatial system without reducing observations to the ellipsoid.

NOS NGS-20 Geodetic leveling and the sea level slope along the California coast. Emery I. Balazs and Bruce C. Douglas, September 1979, 23 pp. Heights of four local mean sea levels for the 1941-59 epoch in California are determined and compared from five geodetic level lines observed (leveled) between 1968-78.

(Continued on inside back cover)

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NOAA Technical Reports, NOS/NGS subseries

NOS 65 NGS 1 The statistics of residuals and the detection of outliers. Allen J. Pope, May 1976, 133 pp (PB258428). A criterion for rejection of bad geodetic data is derived on the basis of residuals from a simultaneous least-squares adjustment. Subroutine TAURE is included.

NOS 66 NGS 2 Effect of Geoceiver observations upon the classical triangulation network. R. E. Moose and S. W. Henriksen, June 1976, 65 pp (PB260921). The use of Geoceiver observations is investigated as a means of improving triangulation network adjustment results.

NOS 67 NGS 3 Algorithms for computing the geopotential using a simple-layer density model. Foster Morrison, March 1977, 41 pp (PB266967). Several algorithms are developed for computing with high accuracy the gravitational attraction of a simple-density layer at arbitrary altitudes. Computer program is included.

NOS 68 NGS 4 Test results of first-order class III leveling. Charles T. Whalen and Emery Balazs, November 1976, 30 pp (GPO# 003-017-00393-1) (PB265421). Specifications for releveling the National vertical control net were tested and the results published.

NOS 70 NGS 5 Selenocentric geodetic reference system. Frederick J. Doyle, Atef A. Elassal, and James R. Lucas, February 1977, 53 pp (PB266046). Reference system was established by simultaneous adjustment of 1,233 metric-camera photographs of the lunar surface from which 2,662 terrain points were positioned.

NOS 71 NGS 6 Application of digital filtering to satellite geodesy. C. C. Goad, May 1977, 73 pp (PB-270192). Variations in the orbit of GEOS-3 were analyzed for M_2 tidal harmonic coefficient values which perturb the orbits of artificial satellites and the Moon.

NOS 72 NGS 7 Systems for the determination of polar motion. Soren W. Henriksen, May 1977, 55 pp (PB274698). Methods for determining polar motion are described and their advantages and disadvantages compared.

NOS 73 NGS 8 Control leveling. Charles T. Whalen, May 1978, 23 pp (GPO# 003-017-00422-8) (PB286838). The history of the National network of geodetic control, from its origin in 1878, is presented in addition to the latest observational and computational procedures.

NOS 74 NGS 9 Survey of the McDonald Observatory radial line scheme by relative lateration techniques. William E. Carter and T. Vincenty, June 1978, 33 pp (PB287427). Results of experimental application of the "ratio method" of electromagnetic distance measurements are given for high resolution crustal deformation studies in the vicinity of the McDonald Lunar Laser Ranging and Harvard Radio Astronomy Stations.

NOS 75 NGS 10 An algorithm to compute the eigenvectors of a symmetric matrix. E. Schmid, August 1978, 5 pp (PB287923). Method describes computations for eigenvalues and eigenvectors of a symmetric matrix.

NOS 76 NGS 11 The application of multiquadric equations and point mass anomaly models to crustal movement studies. Rolland L. Hardy, November 1978, 63 pp (PB293544). Multiquadric equations, both harmonic and non-harmonic, are suitable as geometric prediction functions for surface deformation and have potentiality for usage in analysis of subsurface mass redistribution associated with crustal movements.

NOAA Manuals, NOS/NGS subseries

NOS NGS 1 Geodetic bench marks. Lt. Richard P. Floyd, September 1978, 56 pp (GPO# 003-017-00442-2) (PB296427). Reference guide provides specifications for highly stable bench marks, including chapters on installation procedures, vertical instability, and site selection considerations.

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